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ABSTRACT

This set of 25 instructional modules was produced by a group of industrial arts teacher educators, local teachers, and supervisors from eastern United States. Topic areas of these modules include: societal implications of the energy situation; awareness of energy terms, supply, and use; assessment of conventional and selected renewable alternative energy sources (terms, criteria, availability, consumption, and environment); economic aspects of energy sources; conserving energy through changes in habits, attitudes, and gaining self-sufficiency; energy conservation through the selection and application of renewable alternatives; energy use and reduction in small buildings and homes; principles, practices, and measurement of heat loss and gain; calculating electrical usage; and design criteria for passive solar energy efficient residential construction and other efficiency systems. Additional topics include: energy efficient materials (insulation, vapor barriers, caulking, weatherstripping, doors, windows, storm doors and windows, floors, ceilings, attics, and lighting); energy conservation in private and public transportation; conserving energy through driving habits, automobile maintenance, and automobile engine modification; energy efficiencies in the total automobile operation; home energy management systems; principles and practices of re-using energy supplies; and careers in energy conservation. Modules include objectives, activities, and assessment instruments (with answers). (BC)

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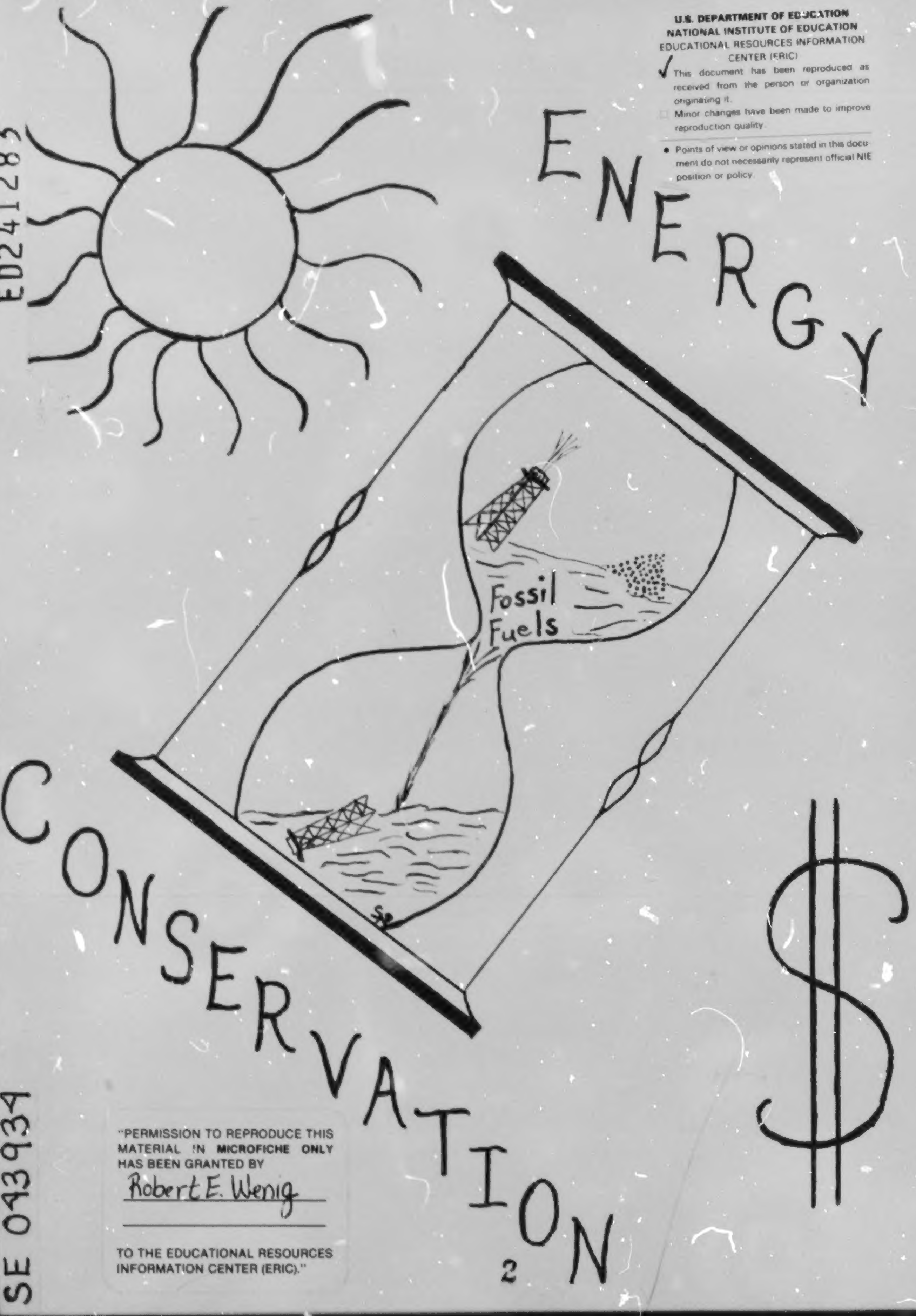
ENERGY CONSERVATION



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U. S. DEPARTMENT OF ENERGY
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NORTH CAROLINA STATE UNIVERSITY AT RALEIGH

ENERGY CONSERVATION: A WORKSHOP FOR SELECTED EASTERN U.S. INDUSTRIAL ARTS TEACHER EDUCATORS

This set of twenty-five Energy Conservation Instructional Modules was produced by a group of industrial arts teacher educators, local teachers, and supervisors from eastern United States. The modules resulted from an intensive eight-day study of energy conservation sponsored by the United States Department of Energy Faculty Development grant held at North Carolina State University, Raleigh, North Carolina, June 16 to 25, 1981, under Contract #DE F605 - 81 CA10125.

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ACKNOWLEDGMENTS

The eight-day energy conservation workshop was considered a great success. To achieve such merit required outstanding performances by those involved. As a measure of my gratitude, I want to thank the following people at North Carolina State University: Dean Carl Dolce (School of Education) for his excellent cooperation and suggestions; Dr. Joseph Clary (Head of Department of Occupational Education) for his exceptional counsel and assistance with policies and procedures; and Irma Hardy, Ruby Wilkerson, and Marian Eastwood (Department of Occupational Education secretaries) for their great secretarial help, suggestions, and efforts on a variety of operational matters.

Besides the exceptional performance of the workshop staff the final draft of the modules was made possible through the efforts of Shirley Pyle (art work) and Janice Nochols and Carol Summers (typing and corrections--secretaries at North Carolina A&T State University).

A special word of thanks goes to Marilyn Wenig for her endless effort and time in typing modules and providing an excellent picnic and luncheon for the participants.

The workshop success belongs to others and especially the outstanding participants. The entire workshop experience will be a highlight of my professional career.

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ABSTRACT

The eight-day summer workshop focused on increasing energy conservation knowledge and skill of selected eastern U.S. industrial arts local teachers and teacher educators. Twenty-four participants spent over 83 hours at the workshop listening to 30 presenters, going on five field trips, and developing instructional modules. All presentations were color video taped on special cassettes from which participants can have copies made. North Carolina State University will serve as a repository for the tapes so that they will not be lost. Each of the 24 participants developed an instructional module on presented workshop topics. The workshop staff edited the developed modules and a set was sent to each participant for use in his/her own teaching situation.

The need for the workshop and its general topics were identified through a survey of selected industrial arts teacher educators in the Eastern U.S. Specific workshop objectives were derived from an analysis of energy conservation library resources and expertise in the Raleigh, North Carolina area. Major topics covered in the workshop included the following: assessment of conventional and selected alternative renewable energy sources; developing a conservation ethic, recognizing energy waste, and applying conservation techniques; identification of current, new, and emerging careers; and fostering cooperation communication among participants so they will openly share information. Objectives were achieved through capable guest lecturers and staff of curriculum developers, graduate student, and the director. Workshop evaluation consisted of using a daily feedback monitoring instrument and an end of workshop DOE participant evaluation form. Overall reaction to the workshop was 54% of the participants said, "Excellent," and 46% said, "Good." Numerous follow-up letters were received from participants telling how much they enjoyed the workshop and especially its management (see Part IV).

PREFACE

The energy crisis began in October 17, 1973 when the Mid East oil-producing countries placed an embargo on their oil shipments. The shock waves from the oil embargo reached around the world, resulting in economic and social disruption in most industrial nations.

While the embargo lasted, it made people keenly aware that in twentieth century America a fourth essential was added to the necessities of life. That is, besides food, clothing, and shelter energy was necessary. No longer could society expect to get energy with so little trouble and expense as in the past.

As the oil embargo continued into 1974 the energy crisis grew more intense. The federal government, with neither stored oil nor immediately accessible oil reserve, met the crisis with the only program that would have immediate effect. It was determined that the best approach to the situation was to set allocations of petroleum products and call for conservation measures. The conservation strategies included reducing highway speed to 55 miles per hour, voluntarily restricting travel, and reducing home heating by lowering thermstats to 68°. The allocation procedure was complex and at times inept. Consumers could purchase gasoline on optional days based on, e.g., license plate odd/even numbers. Where long gas lines developed to purchase fuel, in some incidences, tempers flared.

Some interesting statistics resulted from the conservation measures. For example, gas and oil use dropped by 40 percent the first quarter of 1974. Electricity which has a 7 percent growth rate for years dropped during the embargo to .6 percent. The Gross National Product (a measure of prosperity) fell. Sales of new cars declined 34 percent during the first quarter as compared to same period in 1973, but small car sales jumped 29 percent. One-third (60,000) gasoline service stations closed as the price per gallon of gasoline nearly doubled. Further, as highway speed was reduced to 55 MPH, the death from accidents was cut 25 percent.

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What is the best approach that will enable all society to meet the energy crisis? If an individual seriously examines what caused the problem and reviews various options available to the solution several factors seem clear. These are as follows:

1. Oil and gas provided nearly 72 percent of all energy in United States.

2. The fossil fuel supply (oil and gas) are finite and will increase in cost as they become less and less available.

3. Conventional energy sources (oil, gas, coal, hydro nuclear) and selected alternative sources (solar, wind, nuclear fusion, synfuels, biomass) can provide adequate energy mix, but each has varying problems, e.g., with the environment, availability, and politically.

4. Through emphasis on conservation energy consumption can be reduced and time gained to better develop alternative sources.

Some experts stated that it is easier and cheaper to save the energy we get from conventional sources than it is to generate energy from newer, more expensive sources such as wind and sun. For example, it is cheaper and easier to insulate a home than to produce energy from renewable sources to heat an uninsulated dwelling. If we continue to consume all of our fossil fuels in our cars and vans, we will never see the solar-based society to which we must move if we want to survive. Dollar for dollar energy conservation is one of the best approaches to reducing the energy crisis. It does not cause pollution, it is readily available, each person can contribute, and it will provide resources for future generations to use in maintaining a productive society.

Based on the need to conserve energy the best place to begin for industrial arts education is with their teacher educators who prepare teachers. In turn, these newly prepared industrial arts teachers will spread across the state, region, and nation to instruct hundreds of local school students on energy conservation.

The information presented through the modules will provide a resource that can enable industrial arts educators in eastern United States to move more effectively into energy conservation instruction.

MODULE ONE

SOCIETAL IMPLICATIONS OF THE ENERGY SITUATION

Prepared

by

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Department of Occupational Education
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USDOE Sponsored Faculty Development Workshop on Energy
Conservation for IAE at North Carolina State Univeristy
June, 1981 - R. E. Wenig, Director

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SOCIETAL IMPLICATIONS OF THE ENERGY SITUATION

Since the world energy crisis is an ever-changing situation, this first module (one) will not be the formal beginning. Module two will be the formal introduction to the 24 instructional modules. The intent of this module is to provide a list of general performance objectives with references that could be used to develop a formal module for each participant's instructional situation. Through this informal personalized approach, the introduction of a unit(s) on energy conservation for a specific teaching-learning situation could be more realistically reached. The National Geographic's "A Special Issue on Energy" should serve as the best information to develop the personalized module.

GENERAL PERFORMANCE OBJECTIVES

As a result of participating in this module students will be able to:

1. Discuss the world and national energy predicament.
2. Comprehend six basic truths about energy, i. e.,
    a. We are not running out of energy--yet.
    b. Fossil fuels are, however, finite.
    c. There is no quick fix.
    d. There is no free lunch.
    e. The energy problem is global. What we do effects everyone else.
    f. Energy efficiency and conservation are all-important from now on.
3. Explain why some nations use more energy than others.
4. Discuss how Americans can live better on less.
5. Identify the most appropriate energy mix for American in the future.
6. Discuss the most pressing energy issues and how experts see them.

REFERENCES

(Entire Publication)-A Special Report on Energy, National Geographic. February, 1981.

(Entire Publication)-Energy in the Global Marketplace, U.S. Department of Energy Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830. November, 1978.

(Volume I only)-Energy Environment Source Books: Volume I. Energy,Society and the Environment, National Science Teacher Association, Washington, DC. 1975.

(First Chapter)-Conserve Energy & Save Money, John E. Smith. McCraw Hill. 1981.

(First Chapter)-Energy Primer, (editor) Richard Merrill and Thomas Gage. Delta Special/Seymour Lawrence. New York. 1978.

(Pages 1-15)-Ideas & Activities for Teaching Energy Conservation, Grades 7-12, The University of Tennessee Environment Center, South Stadium Drive, Knoxville, TN, 1977.

(Entire book)-Energy Systems Lesson for Use in Secondary Schools. Energy Education Curriculum Project,Division of Curriculum, Indiana Department of Public Instruction. Indianapolis, IN, 1981.

(Entire pamphlet)-Energy Outlook 1980-2000, Exxon Company, USA's. December, 1980.

Each of the general performance objectives should serve as an INSTRUCTIONAL PACKAGE using the formal module development format, that is:

1. Pre-test
2. Instructional packages 1-6 from general performance objectives
    a. Objectives
    b. Resources
    c. Activities
    d. Objective Checks
3. Post-test Check

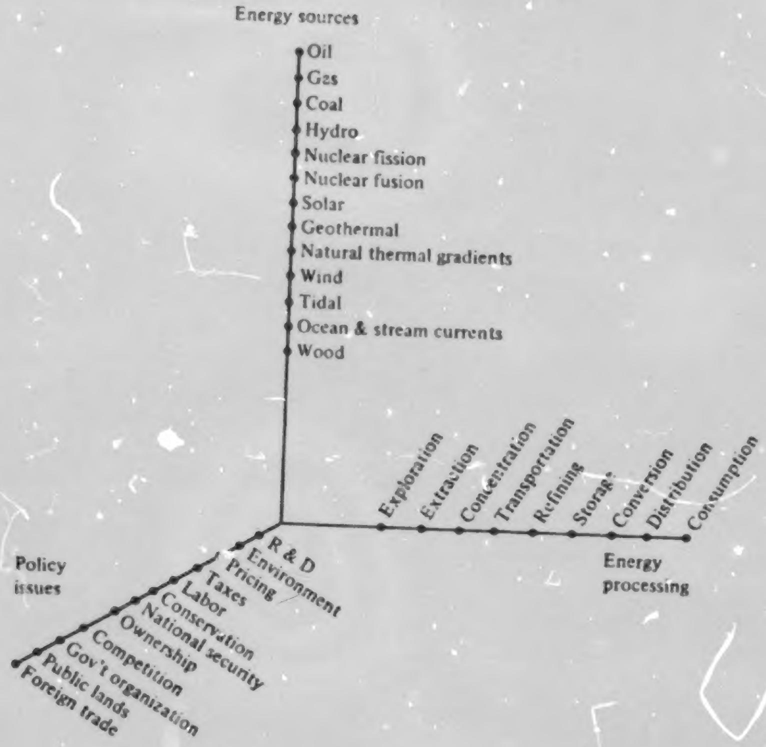

Energy sources
Oil
Gas
Coal
Hydro
Nuclear fission
Nuclear fusion
Solar
Geothermal
Natural thermal gradients
Wind
Tidal
Ocean & stream currents
Wood
Exploration
Extraction
Concentration
Transportation
Refining
Storage
Conversion
Distribution
Consumption
Energy processing
Policy issues
R & D
Environment
Pricing
Taxes
Labor
Conservation
National security
Ownership
Competition
Gov't organization
Public lands
Foreign trade

Fig. 1.11 The three dimensions of the energy issue.

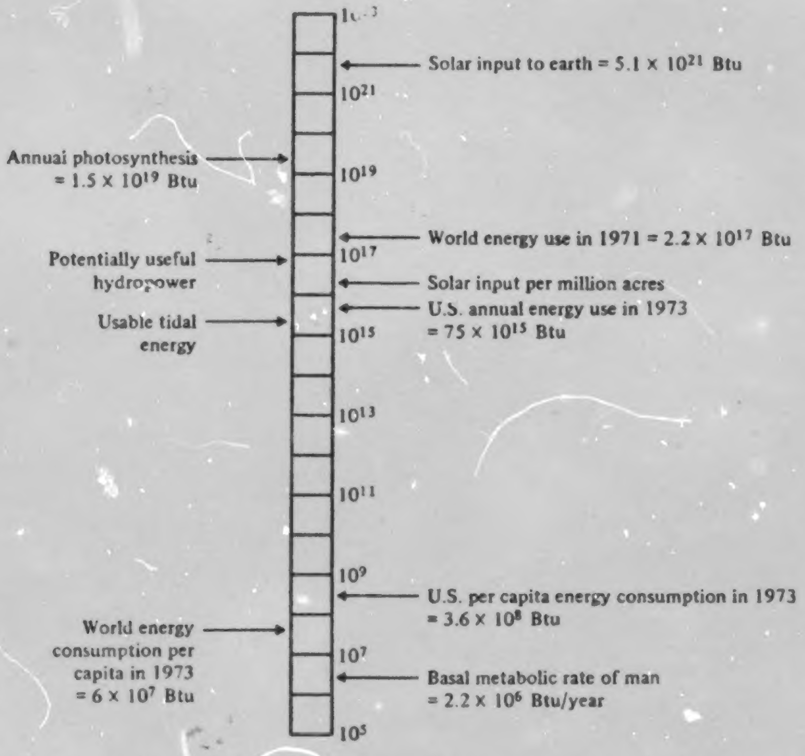


Fig. 2.1 The solar input to the earth and related energy rates. The unit of energy is the British Thermal Unit. (See Chapter 3 for a full discussion of energy units.)

MODULE TWO

AWARENESS OF ENERGY TERMS, SUPPLY, AND USE

Prepared

by

R.T. Troxler
North Carolina State University
Raleigh, North Carolina

USDOE Sponsored Faculty Development Workshop on Energy
Conservation for IAE at North Carolina State University
June 1981 - R.E. Wenig, Director

AWARENESS OF ENERGY TERMS, SUPPLY, AND USE

TERMINAL PERFORMANCE OBJECTIVES

After the completion of this module, the student should be able to:

1. Identify the various terms related to energy.
2. Outline the facts about the supply and utilization of oil energy in the United States.
3. Discuss how the shortage of petroleum energy may change the patterns of life and life style of future generations.

INSTRUCTIONAL PACKAGES

IP-1. Identification and Use of Energy Terms

IP-2. Outline Facts about Energy Supply and Use

IP-3. How Patterns of Life Might Change with Less Energy

PRE-CHECK

AWARENESS OF ENERGY TERMS, SUPPLY, AND USE

IP-1. Energy Terms

_____1. A barrel of crude oil would be:

A. 12 Gallons
B. 65 Gallons
C. 42 Gallons

_____2. A BTU is a:

A. Pound
B. Measure of Heat
C. Distance

_____3. The ratio of useful work or output in relationship to the energy input is called:

A. Foot-Pounds
B. Watts
C. Efficiency

_____4. Fossil fuels come from

A. Alcohol
B. Sand
C. Remains of plants and animals

_____5. Gasohol is made up of a mixture of:

A. 50% Kerosene, 50% Alcohol
B. Regular Gasoline with 10% Alcohol
C. Unleaded Gasoline with 10% Alcohol

_____6. A Quad is:

A. A fraction of a tank of gas.
B. A large quantity of energy
C. The energy in one barrel of crude oil.

_____7. The world's reserve fossil fuel is the amount of fuel equal to:

A. All the gasoline in tanks.
B. The coal which is out of the mines ready for shipment.
c. The fossil fuel which has been discovered, may be economically processed but has not yet been harvested.

_____8. A BTU is the amount of heat energy required to:

A. Raise one pound of water one degree fahrenheit.
B. Do one foot-pound of work.
C. The amount of energy in one gallon of gasoline.

IP-2. Oil Energy Reserve and Use

T F 1. The U.S. is able to produce (domestic supply) all required petroleum energy.

_____2. Of the total energy consumed in the U.S., approximately what percentage is petroleum energy?

A. 60%
B. 45%
C. 8%

_____3. Approximately 25% of our energy is used in transportation. Of this amount, what percentage is used in passenger cars?

A. 20%
B. 90%
C. 60%

_____4. The United States has what percent of the world's oil reserve?

A. 10%
B. 60%
C. 80%

_____5. What percent of our total energy used in the United States comes from petroleum?

A. 15%
B. 45%
C. 80%

T F 6. A chief advantage of oil is that it is easy to transport as compared with other fossil fuels.

T F 7. Approximately one-third of the world's oil supply comes from the Persian Gulf region.

T F 8. Today the world consumes energy equal to 100 million barrels per day. Of this, some 60 million barrels per day is oil.

T F 9. In the U.S. the largest amount of our energy comes from coal.

____10. The largest supply of fossil energy in the U.S. is:

A. Oil
B. Coal

____11. The most likely way the United States may cope with the energy crisis is to:

A. Locate more oil
B. Conserve energy
C. Use bottled gas

T F 12. Most of the experts think we will make a spectacular discovery that will solve our energy problems.

____13. Passenger cars consume what percentage of our oil?

A. 80%
B. 10%
C. 30%

T F 14. Lighting for home and industry uses from 5% to 6% of the total nation's energy consumed.

T F 15. One of the chief problems that face the world is how to decrease the use of energy without decreasing economic growth.

PRE-CHECK KEY

AWARENESS OF ENERGY TERMS, SUPPLY, AND USE

1P-1. Energy Terms

1. C
2. B
3. C
4. C
5. C
6. B
7. C
8. A

1P-2. Oil Energy Reserve and Use

1. F
2. B
3. C
4. A
5. B
6. T
7. T
8. T
9. F
10. B
11. B
12. F
13. C
14. T
15. T

AWARENESS OF ENERGY TERMS, SUPPLY, AND USE

IP-1. Identification and Use of Energy Terms

OBJECTIVES

Upon completion of this package, you will be able to:

A. Identify the important terms used in energy education.

B. Define the meaning of the identified energy terms.

RESOURCES

Enhanced Oil Recovery Potential in the United States. Office of Technology Assessment, Washington, DC.

Environmental Education Strategies for Wise Use of Energy. Division of Science Education, North Carolina Department of Public Instruction, Raleigh, North Carolina 27611.

Energy in the Global Marketplace, U.S. Department of Energy, Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830. November 1978.

A Special Report on Energy. National Geographic, February 1981.

ACTIVITY

A. ENERGY TERMS

1. Barrel - A liquid measure of oil, usually crude oil. Equal to 42 gallons.

2. Barrel of Oil Equivalent - The energy equal to a barrel of crude oil; 5.8 Million BTU's.

3. BTU (British Thermal Unit) - The amount of heat necessary to raise the temperature of one pound of water one degree fahrenheit.

4. Efficiency - The ratio of useful work or energy output to total work or energy input.

5. Energy - Energy is the capacity for doing work. Typical units of energy are BTU, Calorie, Foot-Pound.

6. Fossil Fuels - Fuels such as coal, crude oil, or natural gas, formed from remains of plants and animals.

7. Gasohol - In the U.S., a mix of 90 percent unleaded gasoline and 10 percent ethylalcohol.

8. Greenhouse Effect - The warming effect of carbon dioxide and water vapor in the atmosphere. These molecules allow the sunlight to come through but block infrared (heat) radiation escaping from the earth.

9. OPEC - The Organization of Petroleum Exporting Countries. 13 nations that aim at developing common oil-marketing policies.

10. Petroleum - Mineral oil. Fractional distillation yields gasoline, diesel, lubricating oils, and other products.

11. Power - The rate at which work is done. Typical power units are watts and horsepower.

12. Power Tools - A group of electric power supplies whose transmission lines are interconnected.

13. Quad - A large quantity of energy. (A Quadizillion BTU's) 10^{15} BTU's. The amount of energy contained in eight billion (8,000,000,000) gallons of gasoline. A year's supply for ten million automobiles.

14. Reserve - The reserve fossil fuel energy would be the reserve which has been discovered, not harvested, but may be economically processed and used.

FEEDBACK

Objective A Check:

1. Retake 1P-1 Pre-Check with same instructions. Check your answers.

_C_ 1.
_B_ 2.
_C_ 3.
_C_ 4.
_C_ 5.
_B_ 6.
_C_ 7.
_A_ 8.

AWARENESS OF ENERGY TERMS, SUPPLY, AND USE

IP-2. Outline Facts About Energy Supply and Use

OBJECTIVES

Upon completion of this package, you will be able to:

A. Discuss how energy is supplied and consumed in the world and the U.S.

B. Demonstrate how much energy is used.

RESOURCES

Same as IP-1.

Pamphlet

Energy Outlook 1980 - 2000. Exxon Corporation, December 1980.

2 1

ACTIVITY

A. Review the information found in the set of 10 transparency masters IP-2, 1 - 10.

B. Apply the information found in A above to constructing an energy use time-line indicating eventual crisis.

C. Examine reference material to determine proper energy mix for United States.

Perform the following calculations

1. Calculate the height of a tank the size of a football field to hold the gasoline equal to 1 quad of energy.

   1 Quad of Energy is equal to 8 billion gallons of gasoline (8,000,000,000)
   Cubic Foot = 1728 cubic inches
   1 Gallon - 231 cubic inches
   Football Field = 300 x 160 feet

2. The total number of vehicles registered in North Carolina in 1980 was 4,465,225. (Use 4,465,000 for calculation.) A quad of gasoline energy has been estimated as a year's supply for 10 million automobiles. Assume the vehicles registered were all automobiles. How many quads or what fraction of a quad would be required for the automobiles in North Carolina for one year?

3. Call the Motor Vehicle Department in your state to determine the number of vehicles registered. Calculate the quads of energy necessary for the automobiles for one year.

4. The U.S. imported 7.4 quads of oil in 1970 and 15.2 quads in 1980, an increase of 7.8 quads in ten years. If all 7.8 quads were used for automobiles, how many automobiles would it supply for one year?

5. Make a model of the earth to demonstrate the Greenhouse Effect. Mount two spheres on a dowel. Leave one sphere bare and cover one sphere with clear plastic. Place the models in the sun; measure and compare the temperature of each.

FEEDBACK

Objectives A and B Check:

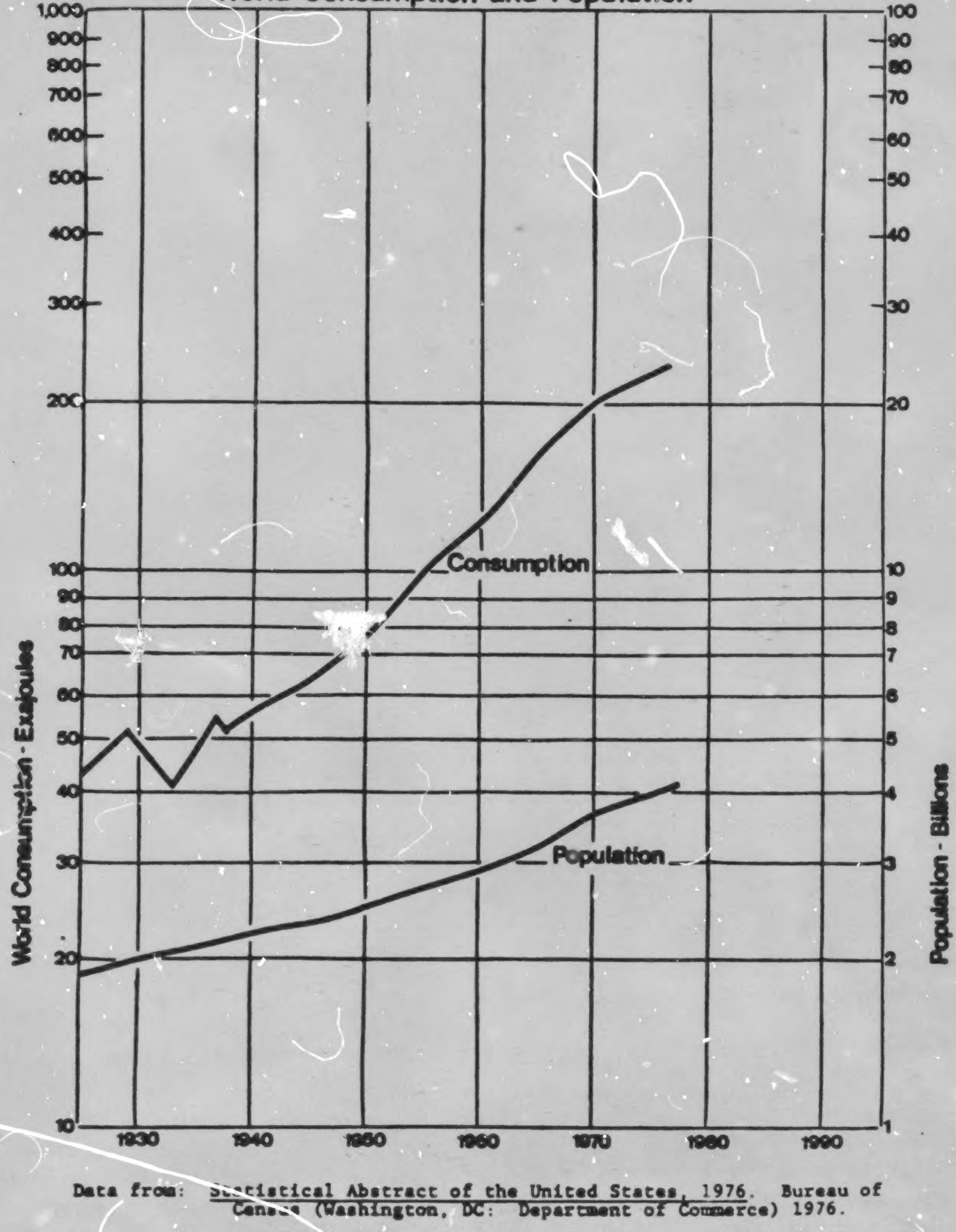
1. Write a report on the supply and use of energy in the world and the U.S.

2. Determine the cost of gasoline required to drive an automobile 10,000 miles with an average miles per gallon of 15, 14, 25, and 36. Use present gasoline price.

FIGURE AB-11

1P-2,1

World Consumption and Population



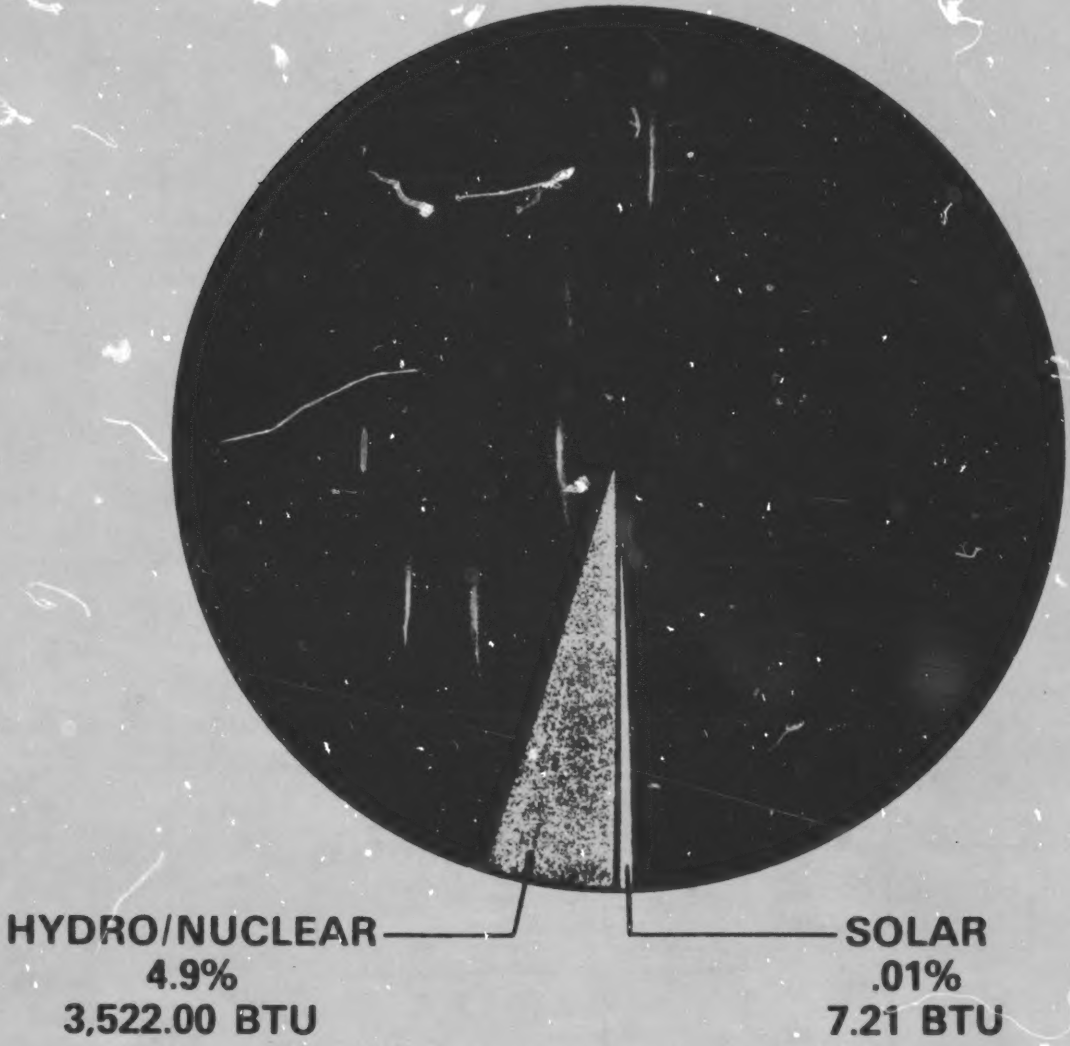
Data from: Statistical Abstract of the United States, 1976. Bureau of Census (Washington, DC: Department of Commerce) 1976.

World Energy Supplies: 1950-1974. Statistical Paper, Series J, #19 (New York: United Nations) 1975.

1P-2, 2

ENERGY CONSUMPTION IN THE U.S.

(%/TRILLION BTU)



Fossil fuels account for nearly 95% of the energy being used in this country. These vital energy sources are rapidly being depleted. It is no longer a question of IF we will run out of fossil fuels; the question is WHEN.

Source: U.S. Bureau of Mines

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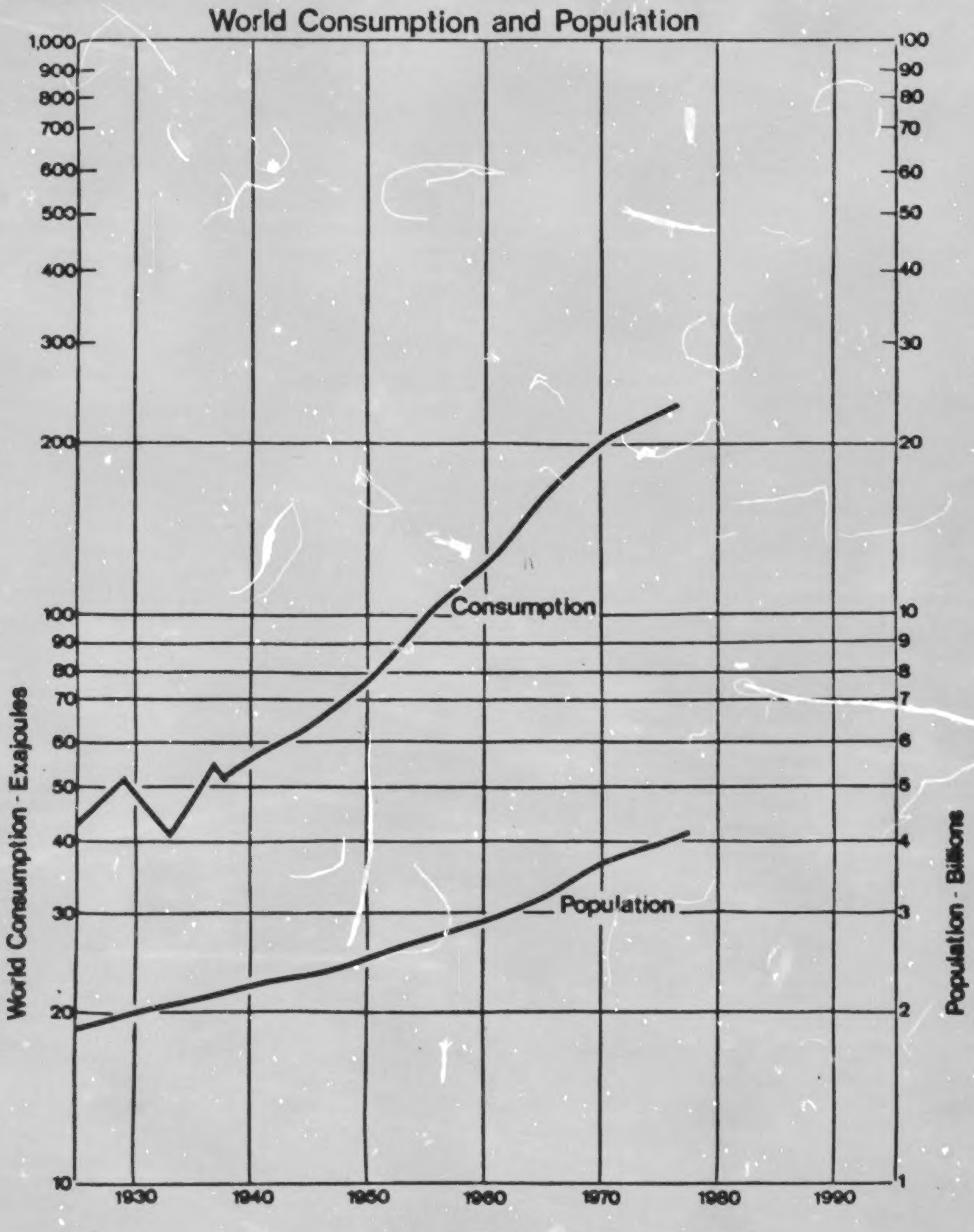
1P-2,3

FIGURE A8-11

World Consumption and Population

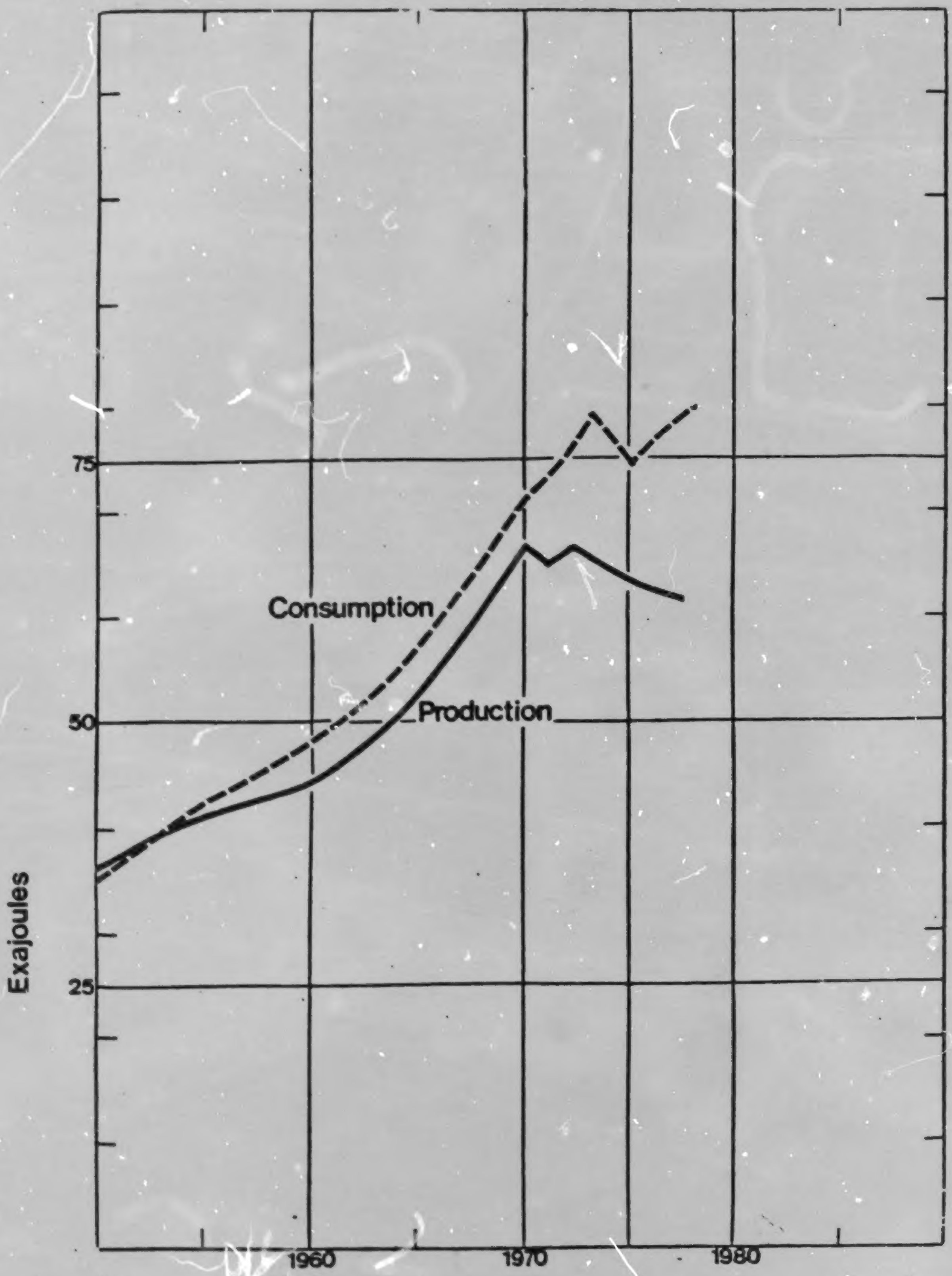


Data from: Statistical Abstract of the United States, 1976. Bureau of Census (Washington, DC: Department of Commerce) 1976.

World Energy Supplies: 1950-1974. Statistical Paper, Series J, #19 (New York: United Nations) 1975.

1 P-2,4

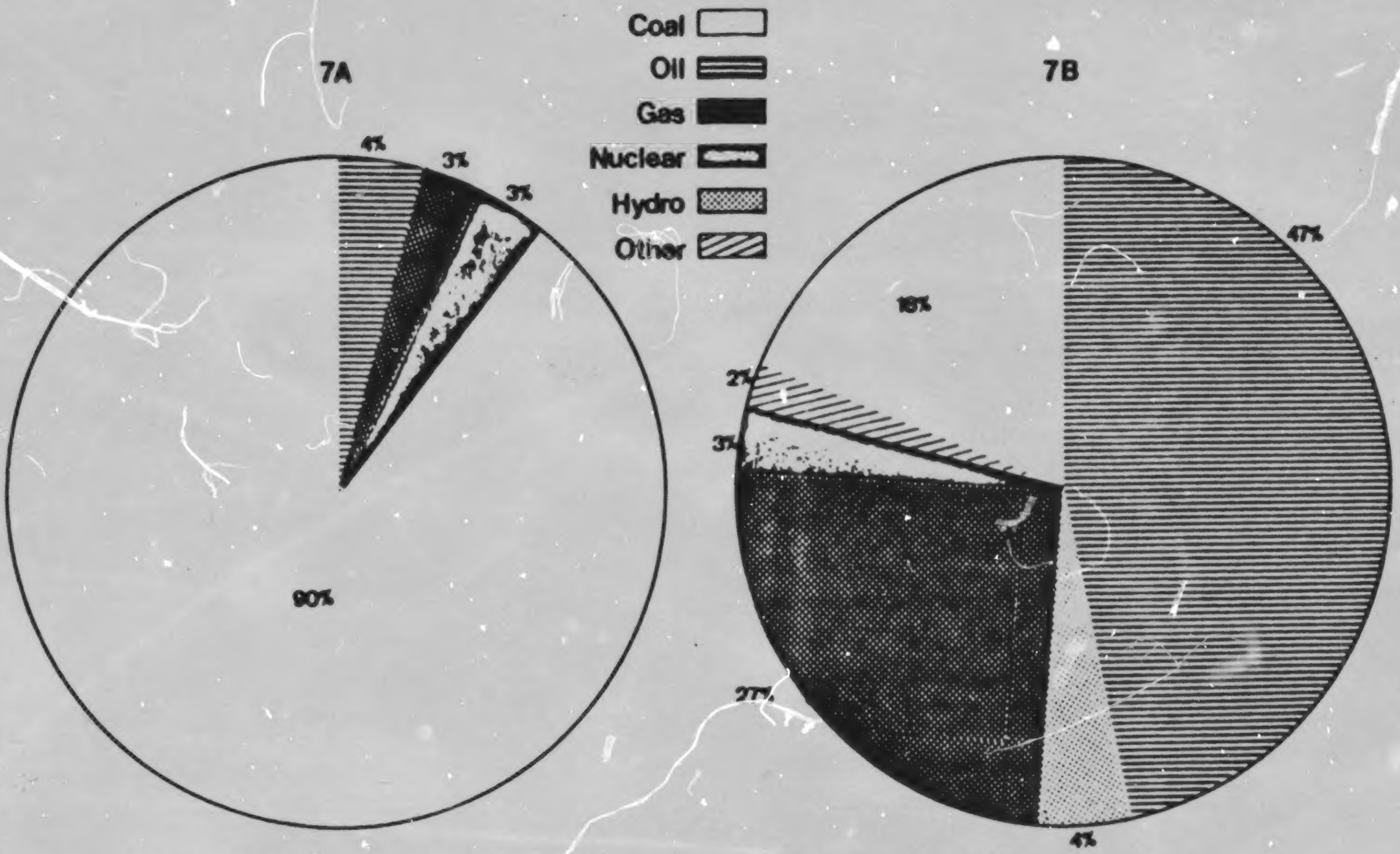
Figure 2 - U.S. Energy Production and Consumption



1P-2,5

6

U.S. Energy Outlook 1977



Proved Reserves Economically Recoverable With Existing Technology

Consumption Pattern

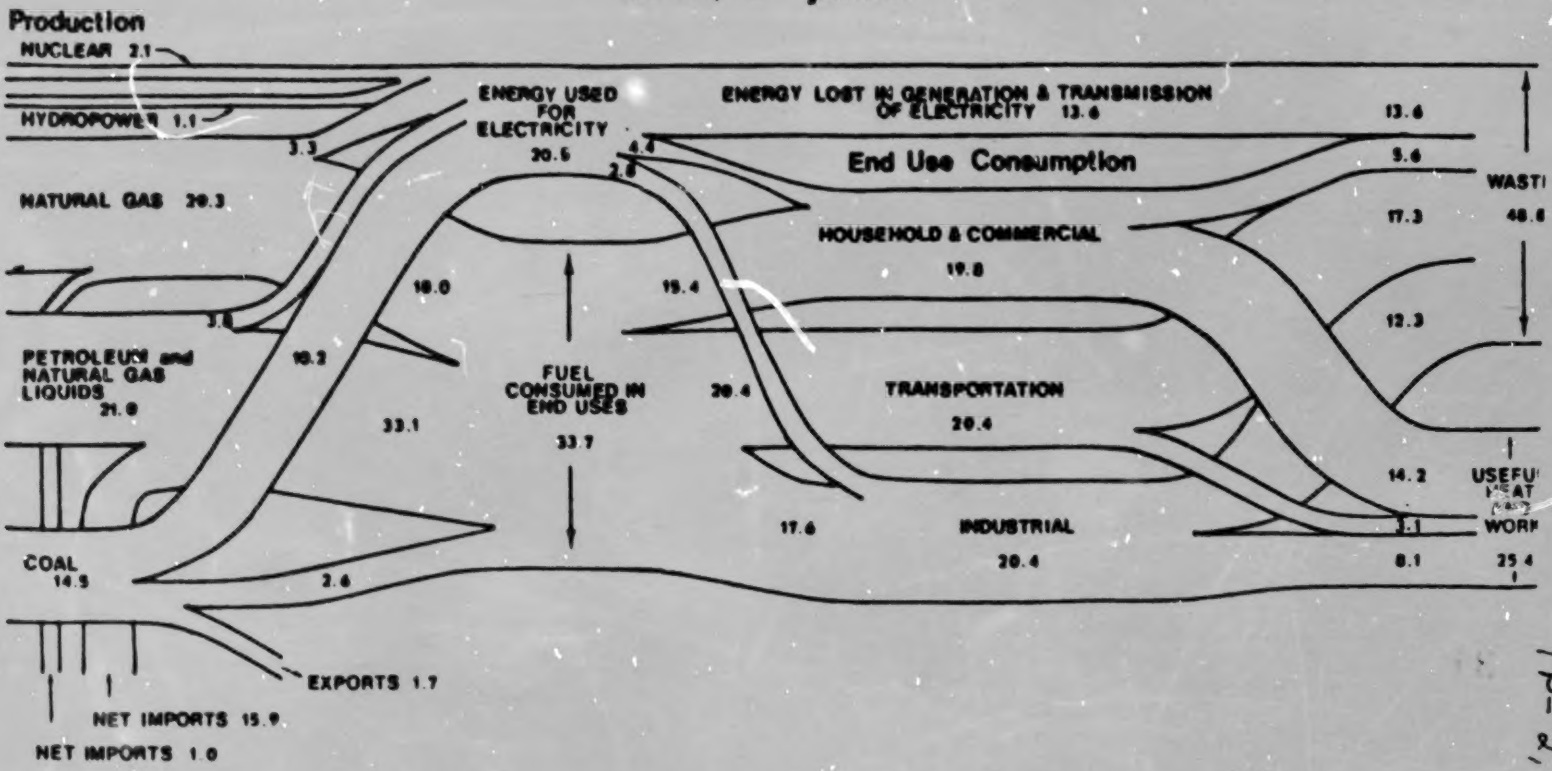
(See Figure AB-6, "Energy Content of U.S. Fossil Fuels.")

Data from: Monthly Energy Review. (Washington, DC: Department of Energy) 1978.

FIGURE A8-3

Energy Flow through the U.S. Economy, 1976

[in EJ, 10^{18} joules]


Production
NUCLEAR 2.1
HYDROPOWER 1.1
3.3
NATURAL GAS 20.3
3.6
PETROLEUM and NATURAL GAS LIQUIDS 21.9
COAL 14.5
NET IMPORTS 15.9
NET IMPORTS 1.0
EXPORTS 1.7
10.2
33.1
2.6
ENERGY USED FOR ELECTRICITY 20.5
18.0
FUEL CONSUMED IN END USES 33.7
4.4
2.8
15.4
20.4
17.6
ENERGY LOST IN GENERATION & TRANSMISSION OF ELECTRICITY 13.6
End Use Consumption
HOUSEHOLD & COMMERCIAL 19.8
TRANSPORTATION 20.4
INDUSTRIAL 20.4
13.6
5.6
17.3
12.3
14.2
3.1
8.1
WAST
48.6
USEFU
HEAT
WORK
25.4

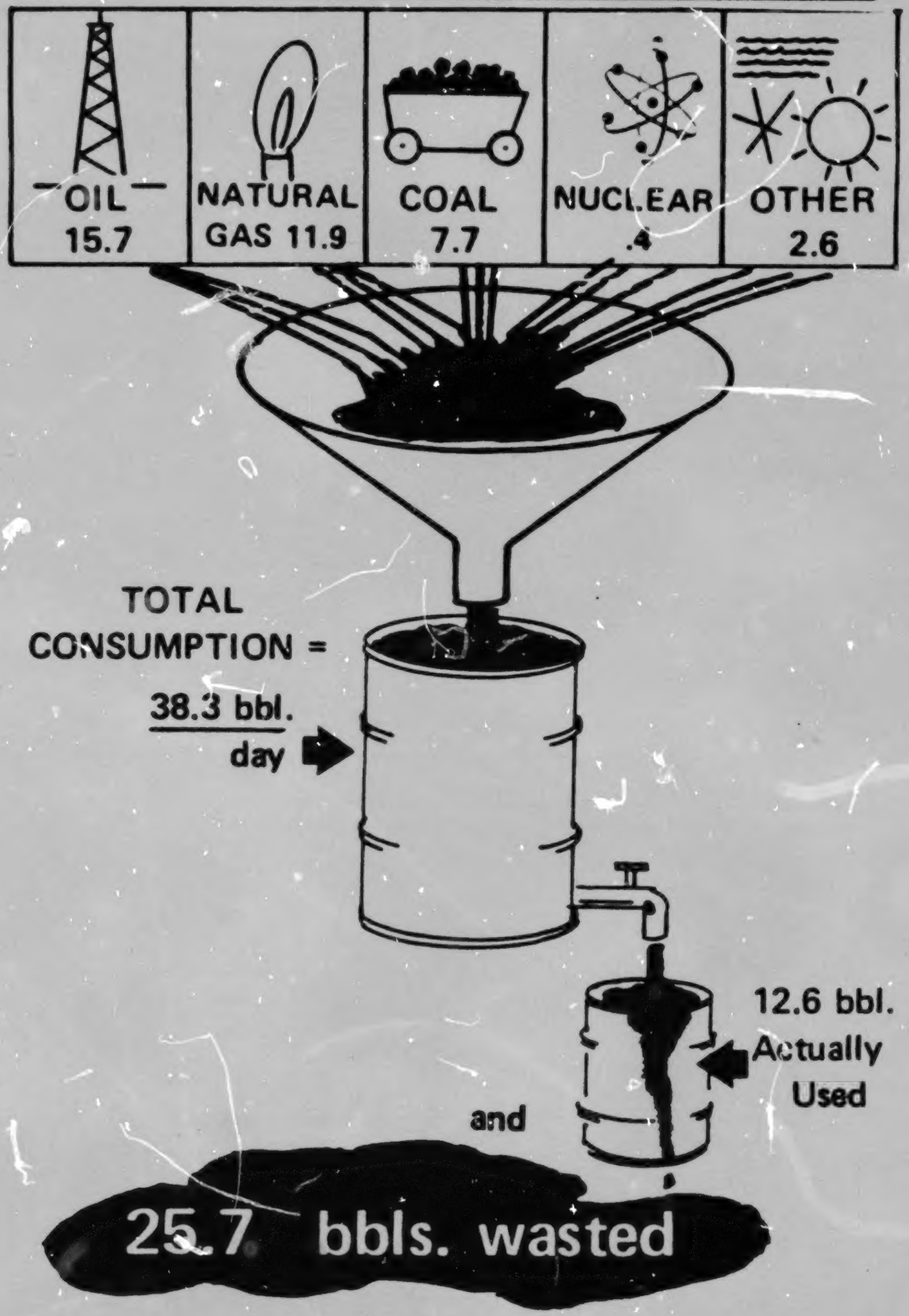
after Earle Cook, Texas A&M University

1P-2,6

1P-2,7

SIZE OF THE ENERGY SYSTEM

IN MILLIONS OF BARRELS PER DAY



OIL
15.7

NATURAL
GAS 11.9

COAL
7.7

NUCLEAR
.4

OTHER
2.6

TOTAL
CONSUMPTION =
38.3 bbl.
day

12.6 bbl.
Actually
Used

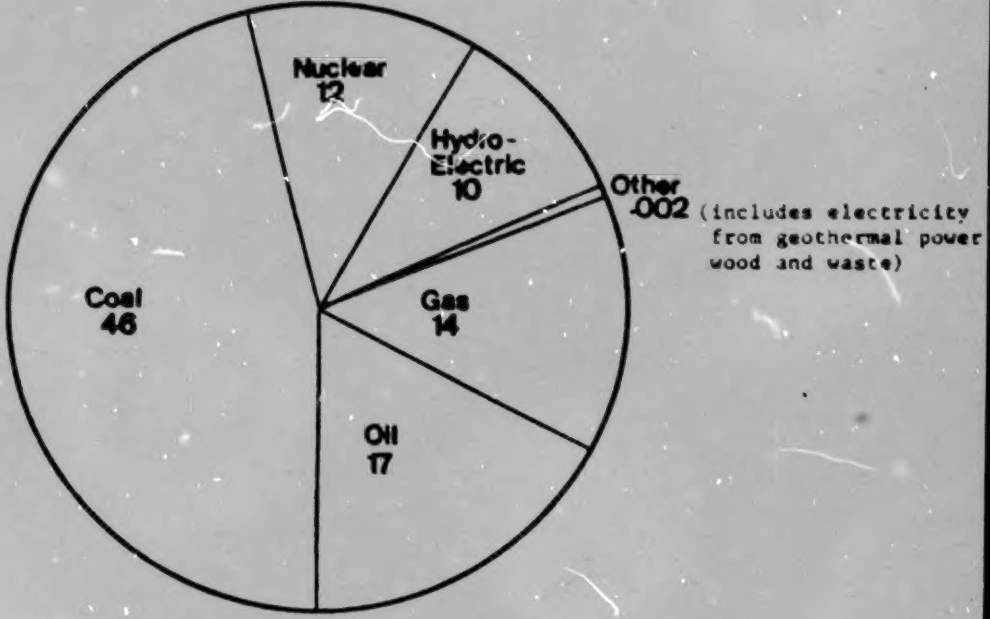
and

25.7 bbls. wasted

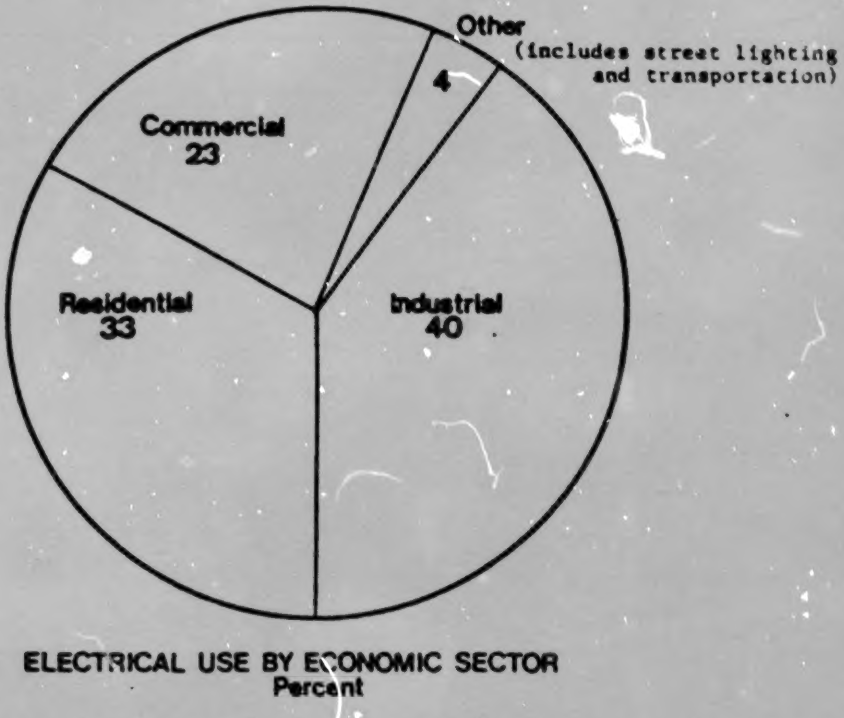
© MINNESOTA MINING AND MANUFACTURING COMPANY 1977 ENERGY–1978

1 P- 2, 8

1977



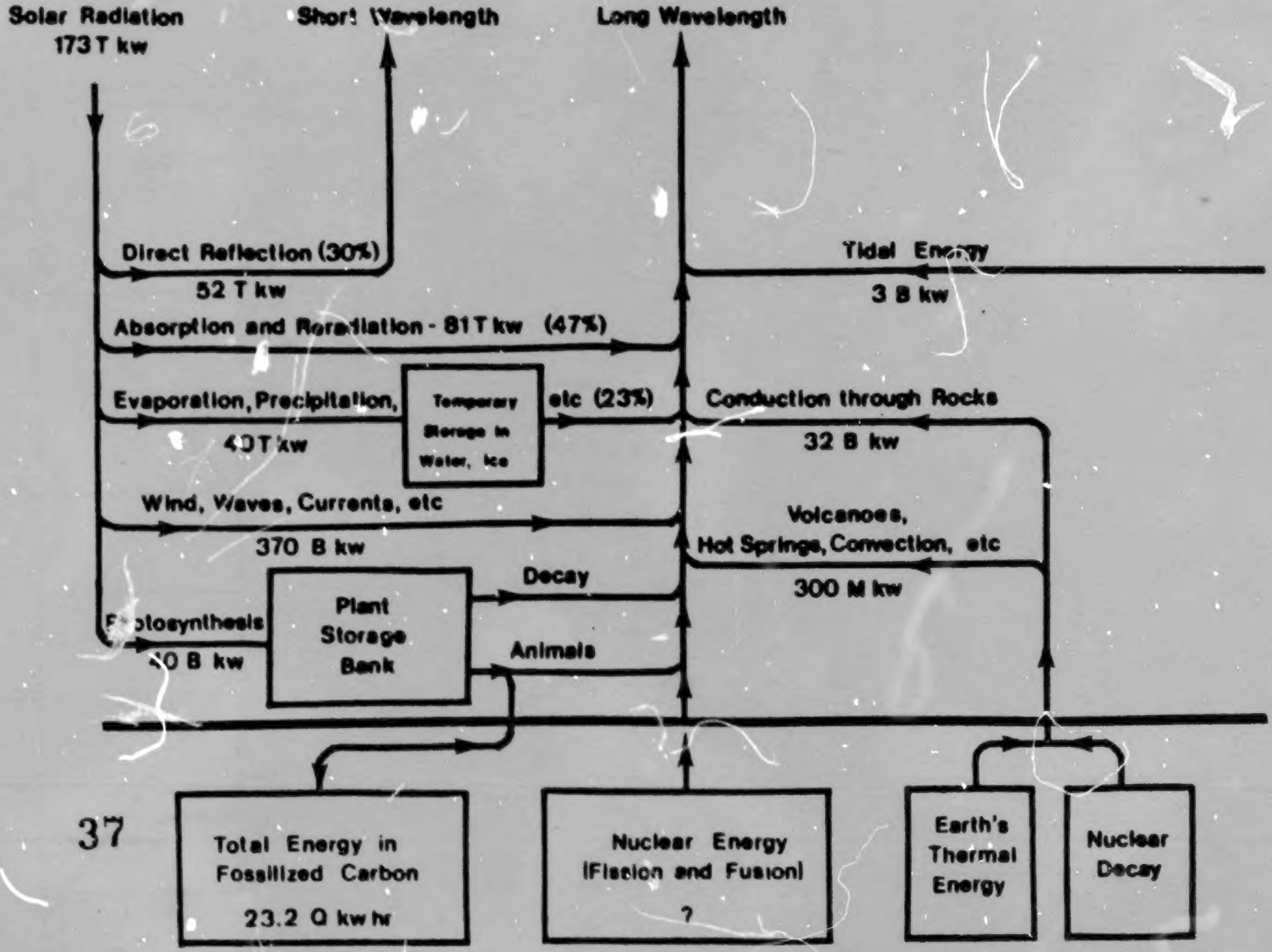
PRIMARY ENERGY FOR ELECTRICAL GENERATION
Percent



ELECTRICAL USE BY ECONOMIC SECTOR
Percent

Data from: Monthly Energy Review. (Washington, DC: Department of Energy) 1978.

Earth's Energy Flow



Solar Radiation
173 T kw

Short Wavelength

Long Wavelength

Direct Reflection (30%)
52 T kw

Absorption and Reradiation - 81 T kw (47%)

Evaporation, Precipitation, etc (23%)
40 T kw

Temporary Storage in Water, Ice

Wind, Waves, Currents, etc
370 B kw

Photosynthesis
40 B kw

Plant Storage Bank

Decay

Animals

Tidal Energy
3 B kw

Conduction through Rocks
32 B kw

Volcanoes, Hot Springs, Convection, etc
300 M kw

Total Energy in Fossilized Carbon
23.2 Q kw hr

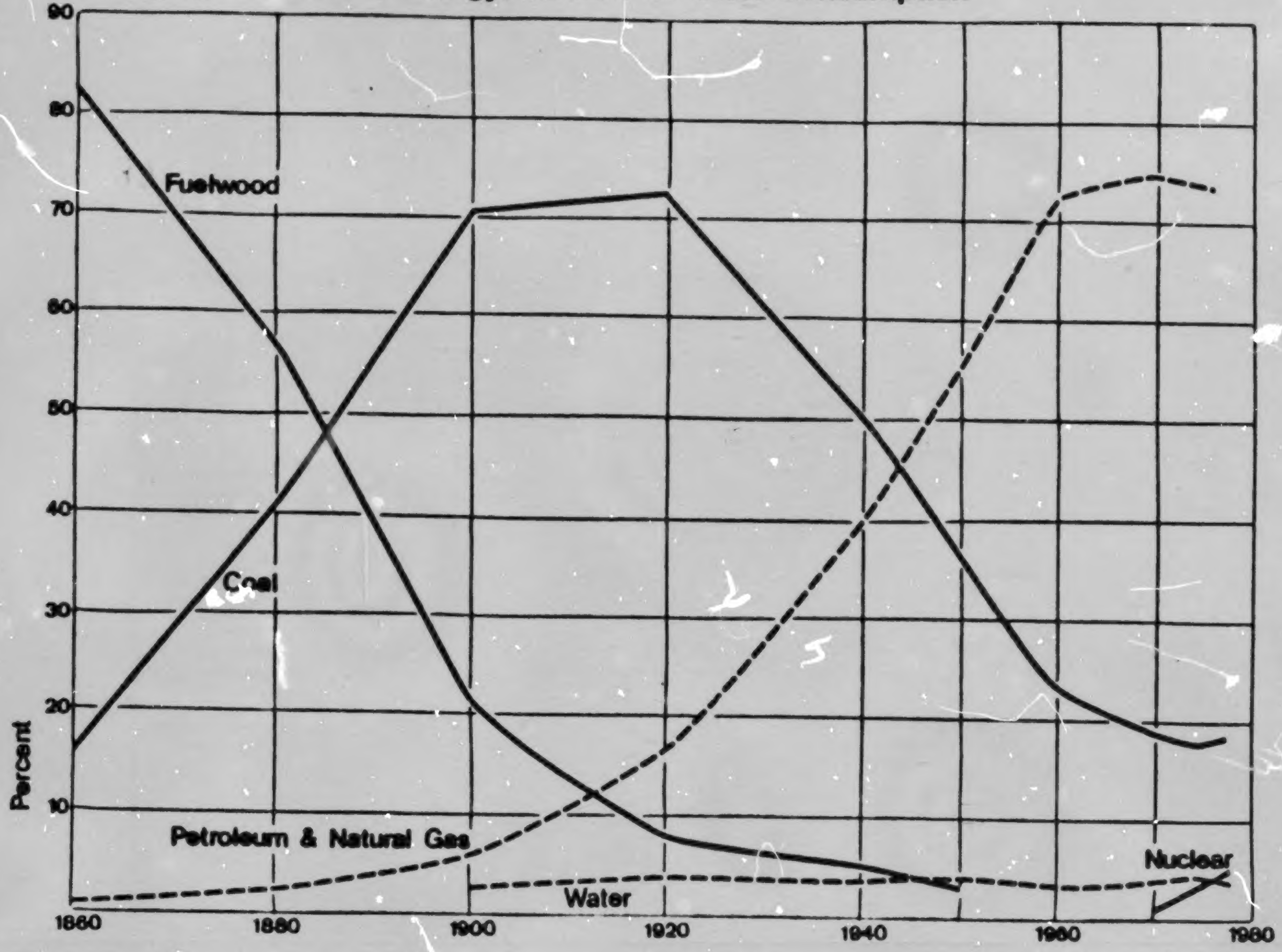
Nuclear Energy (Fission and Fusion)
?

Earth's Thermal Energy

Nuclear Decay

Data from: Ruedisili and Firebaugh. Perspectives on Energy: Issues, Ideas and Environmental Dilemmas. (New York: Oxford University Press) 1978.

Changing Sources of Energy: Percent of Total Consumption



Data from: Energy in Focus: Basic Data. (Washington, DC: Federal Energy Administration) 1977.

Monthly Energy Review. (Washington, DC: Department of Energy) 1978.

BEST COPY AVAILABLE

AWARENESS OF ENERGY TERMS, SUPPLY, AND USE

IP-3. How Pattern of Life Might Change with Less Cheap Energy

OBJECTIVES

Upon completion of this package, you will be able to:

A. Discuss various life style changes due to energy supply and use.

RESOURCES

Same as IP-2 and IP-2.

ACTIVITY

A. How would your life have changed today if the gasoline supply became zero when you woke up this morning?

B. Have one student make a chart or poster to show how many students in the class live in homes or apartments heated with petroleum.

C. How would the patterns of social activity change if the U.S. was forced to become 90% dependent upon public transportation?

D. Have the students do a log of their travel for one week showing:

   1. Number of miles to and from school
   2. Number of miles of public transportation
   3. Number of miles with two people or less in the automobile.

E. Have the students make a study showing any relationship between the stock market and the supply or use of energy.

F. Have the students show how the family income is dependent upon the use of the automobile.

FEEDBACK

Objectives A, B, C, D, E, and F Check:

1. Write a report on energy and present it to the class.

2. Hold a class debate on energy supply and use in the United States now and in the future.

40

POST-CHECK

AWARENESS OF ENERGY TERMS, SUPPLY, AND USE

Directions: Provide the best response on a separate answer sheet that correctly answers each test item.

Multiple Choice: Circle the letter that best completes the statement.

1. The ability to do work is called
   A. horsepower.
   B. force.
   C. energy.
   D. power.

2. Applying force to cause motion is
   A. power.
   B. energy.
   C. force.
   D. work.

3. The rate of doing work is called
   A. control.
   B. energy.
   C. cycle.
   D. power.

4. A device that converts human or animal muscle power, water, wind or heat into a more usable form of energy is a
   A. prime mover.
   B. machine.
   C. transmission.
   D. system.

5. An assembly of parts that transmits forces, motion, and energy one to another in a predetermined manner is called a
   A. system.
   B. control.
   C. machine.
   D. transmission.

6. A device that restrains or has a directing influence over working forces is called a
   A. system.
   B. control.
   C. machine.
   D. transmission.

7. Resistance to relative motion between two bodies in contact is termed
   A. friction.
   B. heat.
   C. pressure.
   D. vacuum.

8. The ratio of force to area is called
   A. efficiency.
   B. vacuum.
   C. friction.
   D. pressure.

9. The performance of a machine compared with its theoretical maximum performance is termed
   A. loss.
   B. efficiency.
   C. friction.
   D. control.

10. The turning effort, or that which tends to cause rotation in a body, is called
   A. torque.
   B. circular energy.
   C. force.
   D. inertia.

11. Energy exerted to cause motion or displacement is called
   A. inertia.
   B. torque.
   C. vacuum.
   D. force.

12. The distance an object moves because of energy exerted on it is termed
   A. displacement.
   B. vacuum.
   C. pressure.
   D. force.

13. A space completely devoid of matter is called a
   A. displacement.
   B. matterless.
   C. complete vacuum.
   D. absence.

14. A group of machines working together to perform a function forms a
   A. cycle.
   B. system.
   C. converter.
   D. control.

15. A method used to relay a force is called a
   A. vacuum.
   B. transmission.
   C. force activator.
   D. crossover.

16. The process of changing energy from one form to another is called
   A. conversion.
   B. transmission.
   C. crossover.
   D. efficiency.

17. The force that causes mechanical machines to do work is called
A. muscle power.
B. fluid power.
C. electrical power.
D. mechanical power.

18. Liquids and gases used under pressure to create motion or do work exercise a force called
A. muscle power.
B. fluid power.
C. electrical power.
D. mechanical power.

19. Force exerted on electrons to create motion or work is called
A. muscle power.
B. fluid power.
C. electrical power.
D. mechanical power.

20. The advantage gained by use of the device that is transmitting the force is termed
A. vacuum displacement.
B. mechanical advantage.
C. conversion process.
D. force multiplication.

21. The force which tends to keep a moving object in motion is known as
A. perpetual motion.
B. momentum.
C. torque.
D. inertia.

22. A course or series of events or operations that recur regularly is a
A. system.
B. cycle.
C. period.
C. pattern.

23. Man's first power sources came from materials which
A. fell.
B. expanded.
C. were burned.
D. absorbed oil.

24. The source of all fuels is
A. the sun.
B. the sea.
C. trees.
D. inner earth.

25. A simple machine cannot increase the amount of
A. force.
B. speed.
C. distance.
D. work.

26. The device used to harness sunlight and convert it into electrical energy is a
    A. thermocouple.
    B. solar cell.
    C. fuel cell.
    D. solar reactor.

27. One of the first natural energy sources used by early man for transportation was
    A. fire.
    B. wind.
    C. steam.
    D. fossil fuels.

28. One of the least polluting fuels is
    A. alcohol.
    B. diesel fuel.
    C. wood.
    D. coal.

29. The most dangerous pollutant resulting from nuclear power is
    A. thermal pollution.
    B. air pollution.
    C. noise pollution.
    D. radioactive contamination.

30. Photochemical smog is created by
    A. sunlight and water vapor.
    B. high temperature and exhaust gases.
    C. exhaust gases and high humidity.
    D. sunlight and exhaust gas.

31. A liquid measure of oil equal to 42 gallons of oil is
    A. quad.
    B. BTU.
    C. barrel.
    D. megawatt.

32. Living matter, plant and animal, in any form is identified as
    A. synfuels.
    B. methane
    C. gasohol
    D. biomass.

33. The alcohol mixed with lead gasoline to make gasohol is named
    A. methane.
    B carcinogen.
    C. ethanol.
    D. denatured.

34. The ratio of useful output (work) based on input is known as
    A. efficiency.
    B. BTU's.
    C. cogeneration.
    D. megawatt.

MODULE THREE

ASSESSMENT OF CONVENTIONAL ENERGY SOURCES

Prepared

by

Glenn Engelke
Wake County Public School System
Raleigh, NC

USDOE Sponsored Faculty Development Workshop on Energy
Conservation for IAE at North Carolina State University
June 1981 - R.E. Wenig, Director

ASSESSMENT OF CONVENTIONAL ENERGY SOURCES

There is an increased interest and critical need for society to become more aware of energy related issues which Industrial Arts Education should teach. Students armed with the use, availability, and society issues related to conventional energy sources will be able to make informed decisions as an individual and a member of society.

TERMINAL PERFORMANCE OBJECTIVE

After completing the module the student will have increased his/her knowledge of the availability, problems, and cost of conventional energy sources. This knowledge will be demonstrated by a grade of 90 percent or better on the Post-Check.

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1.	Assessment of Oil as an Energy Source	____	____
IP-2.	Assessment of Gas an an Energy Source	____	____
IP-3.	Assessment of Coal as an Energy Source	____	____
IP-4.	Assessment of Nuclear as an Energy Source	____	____

PRE-CHECK

ASSESSMENT OF CONVENTIONAL ENERGY SOURCES

If you wish to assess your knowledge of conventional energy sources, take the following Pre-Check:

DIRECTIONS: Circle T for true or F for false.

IP-1. Assessment of Oil as an Energy Source

T F 1. The amount of energy used worldwide is expected to decrease during the 1980's.

T F 2. Oil is normally bought or sold by the ton.

T F 3. In 1980, the U.S. consumed more than a fourth of the worldwide production of oil.

T F 4. Four times as many oil wells have been drilled in the U.S. as in the rest of the world.

IP-2. Assessment of Gas as an Energy Source

T F 1. In 1980, the U.S. was almost self-sufficient in natural gas.

T F 2. The U.S. has sufficient known natural gas reserves to supply our needs for at least 100 years.

T F 3. Unconventional sources of natural gas include shale, tight sands, and geopressured zones.

IP-3. Assessment of Coal as an Energy Source

T F 1. Even if coal use doubles during the next twenty years, supplies are expected to last over 500 years.

T F 2. The United States has more than one-half of the free world's coal resources.

T F 3. One of the major problems with using more coal is pollution from the emissions when it is burned.

T F 4. Coal can be converted to a gas which will burn relatively clean and sulfur free.

PRE-CHECK

(Continued)

IP-4. Assessment of Nuclear as an Energy Source

T F 1. In 1980, only 12 percent of the United States electrical power was being generated with nuclear fuel.

T F 2. Public opinion and government policy are the main obstacles to increasing nuclear electric generation.

T F 3. The U.S. had over 100 operable nuclear electric generating plants in 1980.

T F 4. If nuclear fusion reactors are developed for commercial use, it vastly decreases the need for fuel and the production of radioactive waste.

PRE-CHECK KEY

ASSESSMENT OF CONVENTIONAL ENERGY SOURCES

IP-1. Assessment of Oil as an Energy Source

1. False
2. False
3. True
4. True

IP-2. Assessment of Gas as an Energy Source

1. True
2. False
3. True

IP-3. Assessment of Coal as an Energy Source

1. True
2. True
3. True
4. True

IP-4. Assessment of Nuclear as an Energy Source

1. True
2. True
3. False (about 72)
4. True

ASSESSMENT OF CONVENTIONAL ENERGY SOURCES

IP-1. Assessment of Oil as an Energy Source

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Identify and discuss at least two factors affecting the price of oil.

B. List and discuss three factors that affect the time before our supply of oil is exhausted as a major energy source.

C. Name the limitations of oil supplies.

D. List economic and political effects of depending upon foreign oil.

RESOURCES

Books:

Two Energy Futures: A National Choice for the 80's. American Petroleum Institute, 2102 L Street, NW, Washington, DC 20037, August 1980. 34-54.

Energy-Environment Source Book. National Science Teachers Association: 1742 Connecticut Avenue, NW, Washington, DC 20009, 1975. 115-116.

Magazines:

"Oil Lifeblood." National Geographic, February 1981. pp. 58-59.

50

ACTIVITY

A. Read each of the resources listed.

B. According to the Energy-Environment Source Book, page 116, 52 billion barrels of oil is the total recoverable from identified oil fields in the United States. A chart on page 23 of Two Energy Futures shows a daily production of 10.2 million barrels.

Assuming production remains stable, calculate the number of years before our known recoverable reserves are consumed. (Note: The U.S. consumes over 18 million barrels per day.)

Answer: ____________years

C. What is the immediate problem with depending upon oil as a major energy source? Write two or three sentences (economic-political).

D. What geographic areas of the U.S. have the most potential for new oil discoveries?

E. Read the attached information sheet. Which two sources of energy are predicted to be increased significantly?

1. ______________________________ 2. ______________________________

FEEDBACK

Objective A - D Check:

B. 14 years - 3723 million barrels per year

C. Dependence upon imported oil -- its effect on our economy -- unstable supply line

D. Offshore and Alaska

E. Coal - Nuclear

IP-1 Information Sheet

ALL ENERGY USE IN U.S.A.

	Actual 1979	Predicted 1995
Oil	47.5%	35.1%
Natural Gas	25.5%	16.2%
Coal	19.3%	34.3%
Hydro	4.1%	3.5%
Nuclear	3.5%	11.0%
TOTAL ENERGY USE	78.0 Quad	115.02 Quad

Notes:
1. 73% of all energy used in the U.S.A. during 1979 came from oil and natural gas.
2. One Quad = 10^{15} BTUs = 175,000,000 barrels of oil.

Source: Professor Doolittle, speaker at workshop, 6/16/81

ASSESSMENT OF CONVENTIONAL ENERGY SOURCES

IP-2. Assessment of Gas an an Energy Source

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. List the advantages of gas as a fuel.

B. Discover the supply limits of natural gas.

RESOURCES

Books:

Same as IP-1.

Magazines:

"Natural Gas - Clean, Convenient, and Cheap." National Geographic, February 1981, pp. 60-61.

ACTIVITY

A. Read the resources listed.

B. According to the Energy-Environment Source Book, page 117, 290 trillion cubic feet of natural gas is the total recoverable from identified fields. The annual consumption of natural gas is approximately 21,000 billion cubic feet. Assuming that consumption remains stable, calculate the number of years before our known recoverable reserves are depleted.

Answer: _______years

C. The highest estimate of undiscovered natural gas resources in the U.S. is 655 trillion cubic feet. At a consumption rate of 21,000 billion cubic feet, calculate the number of years before the projected reserves of gas would be depleted.

Answer: ________ years

FEEDBACK

Objective B-C Check:

B. 13.8 years

C. 31.2 years

ASSESSMENT OF CONVENTIONAL ENERGY SOURCES

IP-3. Assessment of Coal as an Energy Source

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Estimate the number of years that coal supplies will last based on present consumption.

B. Name and discuss the environmental problems associated with coal.

RESOURCES

Books:

Two Energy Futures: A National Choice for the 80's. American Petroleum Institute, August 1980, pp. 62-86.

Energy-Environment Source Book. National Science Teachers Association, 1975, pp. 114-115.

Magazines:

Young, C. "Will Coal be Tomorrow's Black Gold?" National Geographic, August 1975, pp. 234-259.

ACTIVITY

A. Read the resources listed.

B. According to the Energy-Environment Source Book, page 115, 3.2 trillion tons of coal is the total U.S. coal resources. Assuming that the annual U.S. consumption of coal approximately doubles to 1,200 million tons, calculate the number of years before our known recoverable resources are depleted.

Answer: ___________years

Note: The U.S. is an exporter of coal and this was not considered in the consumption. Therefore, U.S. production exceeds U.S. consumption and the number of years of reserve is less.

C. Complete the chart below which shows the environmental problems of coal divided as shown.

	SITE	WORKER
	a.	a.
MINING	b.	b.
	c.	c.

	POLLUTANTS	EFFECTS
	a.	a.
BURNING	b.	b.
	c.	
	d.	

FEEDBACK

Objective A-C Check:

B. 2,666 years

C.

SITE	WORKER
a. reclamation of site	a. injuries
b. erosion	b. illness (black lung)
c. pollution of water near site	c. deaths

POLLUTANTS	EFFECTS
a. sulfur oxide	a. acid rains
b. nitrogen oxide	b. greenhouse effect
c. carbon dioxide	
d. particulates (dust, fly ash, etc.)	

IP-4. Assessment of Nuclear as an Energy Source

OBJECTIVES

Upon completion of this instructional page, you will be able to:

A. Cite factors which will affect the amount of energy available from nuclear fuel.

B. List and discuss the advantages of nuclear energy as a fuel.

RESOURCES

Books:

Same as IP-3. (Two Energy Futures, pages 87-94) (Energy-Environment, pages 118-121)

Magazines:

"The Promise and Peril of Nuclear Energy." National Geographic, April 1979. pp. 459-493.

"Uranium - Too Hot to Handle?" National Geographic. February 1981. pp. 66-67.

ACTIVITY

A. Read the resources listed.

B. Refer to resource "The Promise and Peril of Nuclear Energy," *National Geographic*, April 1979, and answer the following questions.

1. What is the cost of a pellet of enriched uranium for a nuclear reactor?
2. The energy content of each pellet is about the same as ________ barrels of oil.
3. What is the minimum dose of radiation that would be lethal to most people?

FEEDBACK

Objective A - B Check:

B. 1. $5 to $10 (p. 461)

2. 4 barrels (p. 461)

3. 600 rems (p. 466)

POST-CHECK

ASSESSMENT OF CONVENTIONAL ENERGY SOURCES

1. Name at least two factors which affect the price of oil.

2. Name two factors which affect the length of time before the world's oil supply is exhausted.

3. Name a man-made material which is developed from fossil fuels.

4. List three economical-political effects of importing quantities of oil at higher and higher prices.

5. The total energy used in the U.S. during 1979 was approximately _______ quads.

6. The total energy use predicted for the U.S. during 1995 is _______ quads.

7. One quad is equal to __________ BTU's.

8. If the U.S. is to continue to use natural gas at the present rate for the next 45 years, we will have to find approximately

   a. 100% B. 200% C. 300% D. 50%

   more than presently known reserves.

9. List at least two advantages of natural gas as a fuel.

10. Which nation has over half the free world's known supply of coal?

11. In 1980, nuclear plants provided about 12% of the electricity produced in the U.S. The electricity out of these plants was equal to approximately __________ million barrels a day of oil.

12. Given the size and number of nuclear reactors which have construction permits or limited work authorizations, experts expect that nuclear energy in the U.S. can:

    a. Double b. Triple c. Quadruple

13. List three factors, other than public opinion, which are limiting the development of nuclear reactors in the U.S.

14. In addition to the problems of mining coal, pollution from burning and solid waste disposal, there is one more obstacle for rapid expansion of coal. It is ____.

POST-CHECK KEY

ASSESSMENT OF CONVENTIONAL ENERGY SOURCES

1. a. supply vs. demand
   b. cost of recovery
   c. cost of exploration
   d. artificial costs added to reduce demand

2. a. conservation
   b. the success of future exploration
   c. development of alternative fuels which can be provided cheaper than oil

3. Plastic

4. a. unfavorable balance of trade
   b. inflation
   c. falling value of the dollar

5. 78 Quad

6. 115. Quad

7. One quadrillion or 10^{15} BTU's

8. c. 300%

9. a. relatively clean burning
   b. few environmental problems in obtaining it from the ground c.
   convenient to use -- continuous delivery
   d. presently cheaper to purchase per BTU

10. The United States

11. 1.3 mbde

12. b. Triple

13. a. enrichment services by federal government
    b. storage of spent fuel
    c. licensing of plant
    d. large capital outlay

14. Transportation (railroad capacity, port capacity, the development of pipelines)

MODULE FOUR

ASSESSMENT OF SELECTED RENEWABLE ALTERNATIVE ENERGY SOURCES - TERMS, CRITERIA, AVAILABILITY, CONSUMPTION, AND ENVIRONMENT

Prepared

by

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USDOE Sponsored Faculty Development Workshop on Energy
Conservation for IAE at North Carolina State University
June 1981 - R.E. Wenig, Director

ASSESSMENT OF SELECTED RENEWABLE ALTERNATIVE ENERGY SOURCES

The field of research and knowledge are expanding rapidly in the area of renewable alternative energy sources. If is not the intention that this module cover the assessment of this whole area. Its purpose is rather to provide a starting point.

TERMINAL PERFORMANCE OBJECTIVE

After completing the module the student will be able to identify the meaning of 90% of the terms used in this module relating to renewable alternative energy sources and their assessment. He or she will also apply evaluative factors included in the module to selected alternative energies.

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1.	Terms	____	____
IP-2.	Solar Energy	____	____
IP-3.	Wind	____	____

PRE-CHECK

ALTERNATIVE ENERGY SOURCE ASSESSMENT

MATCHING

[Select the best match. (Fourteen of the fifteen should be answered correctly to test out of the module.)]

1P-1. Terms   1P-2. Solar Energy   1P-3. Wind

_____1. Wood
_____2. Wind
_____3. Geothermal
_____4. Solar
_____5. Pyrolysis
_____6. OPEC
_____7. Assessment
_____8. Therm
_____9. Biomass
_____10. Silicon
_____11. Degree-Day
_____12. Retrofit
_____13. Gyropower
_____14. Radiation
_____15. Latent

A. Darrieus
B. Ethanol
C. Voltaic cell
D. Combustion
E. Continuous Alternative Source
F. Steam
G. Energy Unit
H. Organic Waste
I. Criteria
J. Trombe Wall
K. Phase Change
L. Inertia
M. Ambient Variation
N. Alternation
O. Electromagnetic

PRE-CHECK KEY

ALTERNATIVE ENERGY SOURCE ASSESSMENT

1P-1.	Terms	1P-2.	Solar Energy	1P-3.	Wind
	1. D				
	2. A				
	3. F				
	4. J				
	5. H				
	6. E				
	7. I				
	8. G				
	9. B				
	10. C				
	11. M				
	12. N				
	13. L				
	14. O				
	15. K				

ALTERNATIVE ENERGY SOURCE ASSESSMENT

IP-1. Terms

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Write out the meaning of 90% of the terms listed in this instructional package.

B. Complete the terms search puzzle and write out the secret message.

C. List at least five (5) reference sources including books and magazines (from the local library or wherever) on the topic of alternative energy sources.

RESOURCES

Books:

Successfuly Alternative Energy Methods. Ritchie, James. Structures Publishing Co: 24277 Ludoplex Circle, Box 1002, Farmington, MI, 1980.

Introduction to Energy Technology. Shepard, M.L., et al. Ann Arbor Science Publishers, Inc.: Box 1425, Ann Arbor, MI, Softcover, 1978.

ACTIVITY

A. Write out the meaning of each of the following terms:

Alternative -

Assessment -

Biomass -

BTU -

COP -

Cell -

Collector -

Criteria -

Current -

Darrieus -

Degree Day -

Efficiency -

Ethanol -

Fuels -

Geothermal -

Gyropower -

Heat -

Hybrid -

Latent -

Methanol -

OPEC -

Payback -

Passive -

Photosynthesis -

Pyrolysis -

Radiation -

Renewable -

Retrofit -

Savonius -

Silicon -

Solar -

Still -

Temperature -

Therm -

Tide -

Trombe -

Waste -

Waterwheel -

Waves -

Wind -

Wood -

R Factor -

U Factor -

ACTIVITY (Continued)

B. Enclose the terms of this unit in a box as illustrated and write out the secret message.

Write to Doug
for this - .

C. List at least five (5) reference sources from the library or elsewhere. These can be books or magazines with appropriate articles relating to alternative energy sources. Include a comment of content on each reference.

Identify by listing the conventional energy sources as opposed to alternative energy sources.

FEEDBACK

Objective A - C Check:

1. Turn in your written term meanings.
2. Turn in your completed terms search puzzle.
3. Turn in your annotated reference list and list of conventional energy sources.

IP-2. Solar Energy

You have learned from the terms search puzzle that solar energy is our primary source of energy here on earth. The sun not only provides our warmth and daylight, it causes our weather including the wind, rain, snow, the rivers with their hydro-power, ocean tides (with the moon) and ocean currents, and also all of our food and fuels. Animals are dependent upon plants and plants are produced through a process of photosynthesis. This process is also necessary for producing present fuels including wood, alcohol, and others along with our conventional fossil fuels, which formed over millions of years under extreme pressure.

We are also continuing to learn how to use the sun more directly through solar heat both passive and active. We are applying solar to the heating of our homes, water, and other processes. There is much to be learned about solar energy.

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Locate an article that compares solar systems and indicates three pros and cons for various systems.

B. Construct a coffee can solar collector and compare three types of cover materials and different types insulation and discuss the results.

C. Locate a solar installation in the area and make a simple sketch of it indicating the type and purpose.

RESOURCES

Books:

Solar Houses - 48 Energy-Saving Designs. Gropp, Louis. A House and Garden Book, Pantheon Books, a Division of Random House, Inc., New York, 1978.

Energy Primer - Solar, Water, Wind, and Biofuels. Merrill, Richard, and Thomas Gage. Dell Publishing Co., Inc.: 1 Dag Hammarskjold Plaza, New York, NY 10017, Revised Edition, 1978.

Solar Energy Project - An Overview. U.S. Dept. of Energy, Assistant Secretary for Conservation and Solar Energy, Office of Solar Applications, Washington, DC 20585, DOE/CS-0124, 1980.

RESOURCES (Continued)

Books:

Factsheets and Other Materials. National Science Teachers Association, Dept. of Energy, Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830.

Magazines:

Solar Age and New Shelter. News Stand.

Instructional Sheet: IP-2-2

ACTIVITY

A. Locate an article from a source such as "Solar Age" or "New Shelter," (May/June 1981, "Five Solar Systems Compared: Which One is Best for You"?) that compares solar systems and list three pros and cons for three of the systems.

B. From DOE/CS-0124 - Construct a Coffee Can Solar Collector as indicated and graph the results. The materials needed will be:

one 1 lb. coffee can with plastic cover or similar can

one 3 lb. coffee can with plastic cover or similar can

one standard laboratory thermometer (-10 C to 110 C)

Assorted pieces of transparent and translucent materials such as plastic wrap, polyethylene, waxed paper, etc. (large enough to cover the small can)

one watch or clock with second hand

one can of flat black spray paint

C. Locate a solar installation in the area and make a sketch of it. Indicate the type of installation (passive, active, or hybrid) and its purpose (water heating, space heating, or combination) using what process. Please explain.

*SEE INSTRUCTIONAL SHEETS IP-2-1 and IP-2-2.

FEEDBACK

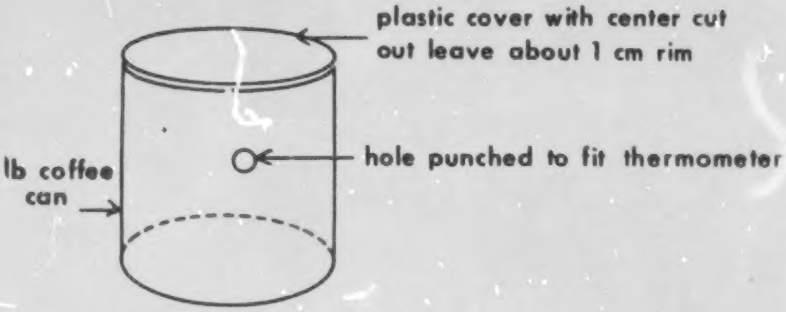
Objective A-C Check:

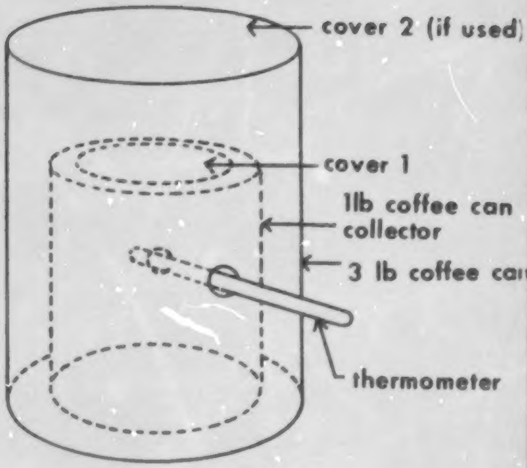
A. Turn in your comparative article evaluations.

B. Turn in your graph obtained from the Coffee Can Solar Collector.

C. Turn in your sketch and comments of the solar installation.

SOLAR ENERGY IN A COFFEE CAN


plastic cover with center cut out leave about 1 cm rim
hole punched to fit thermometer
lb coffee can


cover 2 (if used)
cover 1
1lb coffee can collector
3 lb coffee ca
thermometer

METHOD

1. Spray the inside of the smaller can with black paint.
2. Punch a hole in the side of the small can to fit the thermometer.
3. Punch a hole in the outer can so that the thermometer can pass through it. Allow for the insulation being placed in the outer can. Small can will rest on this, not on the bottom of the outer can.
4. Cut the center out of the small can's plastic lid, leaving a 1cm. rim. (See diagram above).
5. Choose one of the cover materials to stretch across the top of the smaller can. Hold the material secure by replacing the cut out plastic lid.
6. Put the small can inside the larger can.
7. Insert the thermometer through the hole in the large can and then fit it snugly into the smaller inside can.
8. Place your solar collector in the sun and record the temperature each minute for 15 minutes.
9. Plot the data, temperature vs. time, on a graph. Compare your results to the results of those students who used other cover materials.

IP-2, 1-2

10. Repeat procedures #7 and #8, but this time use an insulation material such as cotton. Make sure you put the insulating material in all the spaces between the two cans including the space underneath the center can. After you collect this data for cotton, try 3 or 4 other insulation materials.

11. Compare, on the same set of graph axes, the various types of insulation used. You may need to ask your teacher to help you with this graph.

LOOKING BACK

Solar collectors can be made from a variety of inexpensive, readily available materials. The goal of the design is to permit the solar energy to be trapped and converted into heat. One indication of collector performance is the change in air temperature achieved. Collector performance can be changed by altering the covering material through which the sun's rays pass and altering the insulation materials used.

QUESTIONS

1. According to your graphs, which type of cover material on the small can appeared to be most effective?

2. Why is it necessary to use insulation in a solar collector? Which type of insulation seemed to work best?

3. Of those materials you used, which combination of glazing and insulation material would you recommend for a solar collector?

GOING FURTHER

- What effect does the slant of a collector have on the temperature attained? Try different angles of orientation (slant toward the sun).

- What effect would sub-freezing temperatures outdoors have on temperatures attained? Would solar collectors be practical in colder climates?

- How do wind or cloud cover affect the collector's performance?

- How would adding an additional cover to the outside can affect performance?

- Would changing the color of the inside of the small can affect the energy collected?

ASSESSMENT OF ALTERNATIVE ENERGY SOURCES

IP-3. Wind

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Classify twenty (20) wind energy converters as illustrated according to drag and axis factors.

B. Match the names of ten (10) wind machines with their illustrations.

C. Construct an anemometer with simple materials as illustrated in the activity.

D. Use the anemometer to take and record wind speed measurements in his or her area.

E. Apply two equations concerning wind velocity and blade diameter as given in the introduction and work two wind problems.

RESOURCES

Books:

Power, Primer Mover of Technology. Duffy, Joseph W. Bloomington, IL: McKnight, p. 13-15.

Wind and Windspinners. Hacklemann, A. and W. House. Earthwind: Saugres, Ca

The Dutch Windmill. Stokhuyzen, Frederick. Universe Books: New York, 1963.

Producing Your Own Power. Stover, Carol. Rodale Press: Ermaaus, PA, 1974.

The English Windmill. Wailes, Rex. Routeledge and K. Paul: London, 1967.

Magazines:

"Watts from the Wind." Buckwalter, L. Mechanix Illustrated, March 1975, pp. 40-41.

"Interest in Winds Is Picking Up as Fuels Dwindle." Clark, W. Smithsonian, November 1973, p. 70.

"Overview of WECS Program." Divone, L. Proceedings of the Second Workshop on World Energy Conservation Systems, ERDA, Washington, DC, June 9-11, 1975.

RESOURCES (Continued)

Magazines:

Building a Wind Tunnel. *Estes Industries*, Technical Report TR-5. Penrose, CO, 1965.

"Can We Harness the Wind?" Hamilton, R. *National Geographic*, December 1975, pp. 812-828.

"Measure the Speed of the Wind." Hawkins, H. and J. Ferliot. *Industrial Edcation*, May/June 1975, p. 46-49.

"Windpower." Kruger, J. *Popular Science*, January 1976, p. 103.

"He Rides on the Wind." Lindsey, E.F. *Popular Science*, August 1975, p. 56-59.

"Windpower in a Drum." Moran, E. *Popular Science*, August 1975, p. 104.

"Wind-powered Shop." Moran, E. *Popular Science*, July 1976, p. 93.

"Eggbeater Windmill." Stepler, R. *Popular Science*, May 1975, p. 74-76.

"The American Scientist." Strong, C.L. *Scientific American*, October 1971, p. 108.

"A Windcharger for the Attic." Torginon, J. *Mechanix Illustrated*, March 1976, p. 31-33.

"Wind Power." *Popular Science*, March 1975, p. 82.

Other:

Energy Conservation Resources for Education. Department of Industrial Education, Texas A&M University, College Station, Texas.

Instructional Sheets, IP-3-1 - IP-3-16.

Instructional Sheet IP-3-1

WIND ENERGY

Introduction

Harnessing the Wind

We cannot begin to replenish the stored energy of the earth quickly enough to meet future energy use levels. Ninety-six percent of the U. S. energy is now produced by fossil fuels and the fossil fuels are being used up rapidly.

A growing number of scientistS seek to harness the constant, dependable renewable energy of the sun to heat and cool buildings as well as to produce electricity. One concentrated by-product of solar energy is the wind. In the 1920's and 1930's, before the power companies ran their lines into many rural areas, wind power had a brief popularity. Some 50,000 small wind machines each producing three (3) to ten (10) killowatts were sold to people living in the United States. Most of the generators were taken down or allowed to rust when rural electrification became available.

Today, sales are booming again. People are buying small wind generators as fast as they can be manufactured. Energy planners in government and industry are taking windmills very seriously.

During the past 40 years, the Russians, Danes, Germans, and British have built large windmills in search of low-cost design for a wind energy conversion system (WECS). The most massive experimental windmill was American-made, built during World War II on Grandpa's Knob, a hill outside Rutland, Vermont. The machine was 110 feet high, and the two blades of the propeller, joined at the hub, together were 175 feet long. This was not the only large system attempted. All of these experimental efforts dating back to the 1930's worked proving their technical feasibility. Currently, the capital cost per KW for high performance WECS is too high to compete with most other forms of energy. However, the continuous increase in costs for fossil fuels added to research findings for lower WECS costs will soon make wind generators economically feasible. Advantages of WECS are summarized below:

a. Feasible alternative source

b. Non-depletable supply

c. Independent of foreign sources

d. Exportable technology and products

e. Moderate sophistication

f. Low environmental impact (no pollution)

The Effect of Wind Speed and Rotor Size

When the wind velocity increases, the power derived from the wind increases. To find out how much the power increases, divide the second wind speed by the first wind speed and cube the results. For example, on Tuesday the wind speed is 10 mph and on Wednesday it is 20 mph. What is the difference in the amount of power that could be produced on Wednesday?

$$\frac{20\text{ mph}^{3}}{(10\text{ mph})} = (2)^{3} = 8$$

There would be eight times as much power available on Wednesday as there was on Tuesday.

Also, when the blade (or propeller) diameter increases, the power increases. To find the power increase, divide the larger blade diameter by the smaller blade diamenter and square that fraction. For example, a 200 ft. blade will produce $(2)^2$ or 4 times the amount of power as a 100 ft. blade.

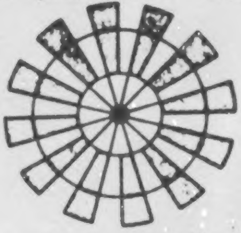
$$\frac{200\text{ ft.}^{2}}{(100\text{ ft.})} = (2)^{2} = 4$$

An increase in the number of blades will provide more turning force at low speeds. This concept is used for water pumping. Fewer blades provide more energy for their cost. In small wind machines with blades 20 to 40 feet in diameter, three blades are probably best in terms of cost and balance. In larger wind turbines two blades are better.

Types of Wind Energy Conversion Systems

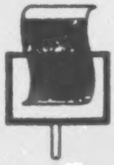
Machines with rotors

1. Horizontal axis rotors (head-on): the axis of rotation is parallel to the windstream.

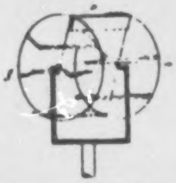


U.S. Farm Windmill Multi-Bladed

2. Cross-wind horizontal axis rotors: the axis of rotation is both horizontal to the surface of the earth and perpendicular to the direction of the windstream, somewhat like a waterwheel. Not very effective.

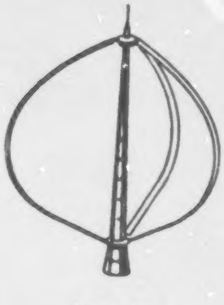


Cross-wind Savonius

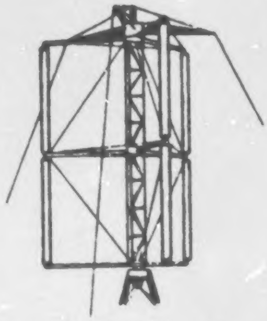


Cross-wind Paddles

3. Vertical-axis rotors: the axis of rotation is perpendicular to both the surface of the earth and the windstream.



φ-Darrieus

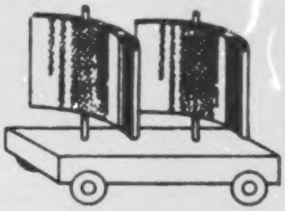


Giromill

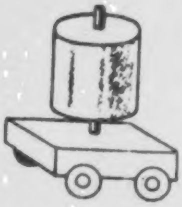
IP-3, 1-4

Translational wind machines

1. Sailing ships
2. Sailing ships that carry water-driven turbines mechanically connected to an electric generator.
3. Land vehicles driven by sails or solid airfoils on a closed track or roadway with their wheels mechanically linked to an electric generator.



Airfoil

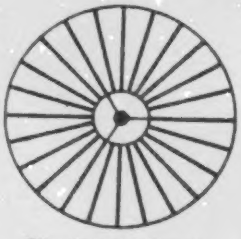


Magnus

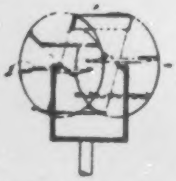
Horizontal axis rotors

1. Can be either lift or drag devices.

LIFT-TYPE



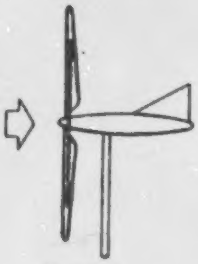
Bicycle Multi-Bladed



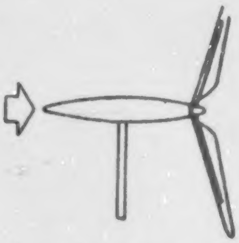
Cross-wind Paddles

DRAG-TYPE

2. May be either up-wind or down-wind rotors.



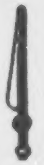
Up-Wind



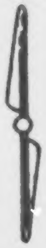
Down-Wind

1 P- 3, 1-5

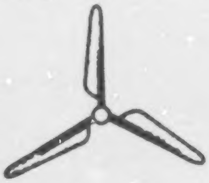
3. Can be designed with different numbers of blades, ranging from one-bladed devices with a counterweight, to devices with large number of blades.



Single-Bladed



Double-Bladed

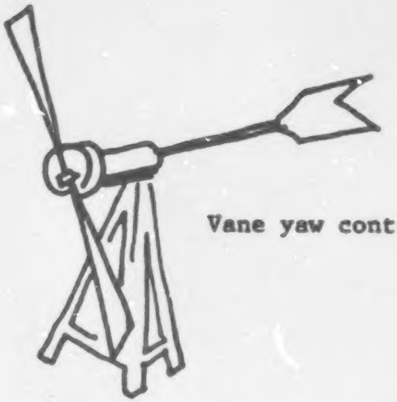


Three-Bladed

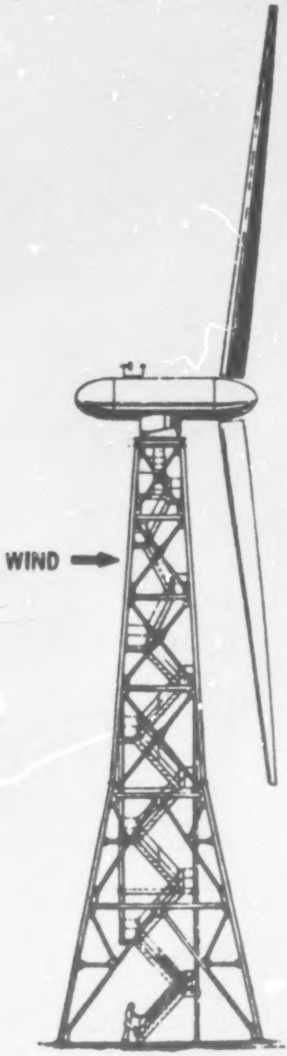
4. May be either yaw-fixed or yaw-active.

   a. Yaw-fixed cannot be rotated into the wind--used where provailing winds are from one direction.

   b. Yaw-active will "track" the changing direction of the wind. Small systems use a tail-vane, whereas larger systems are normally servo controlled.



Vane yaw control

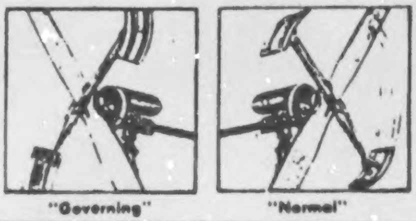


Servo yaw control

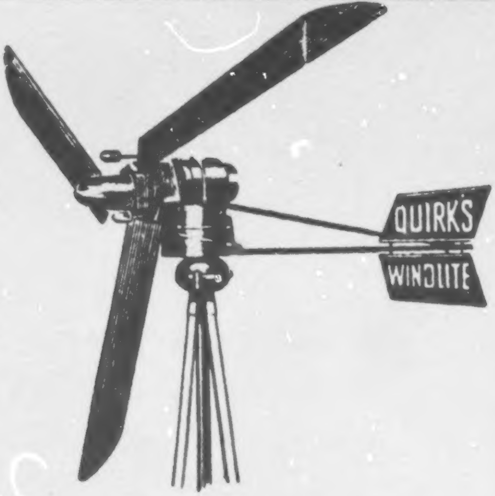
80

5. Propeller speed control (overspeed protection)
   - a. Changing the pitch of the blades.
   - b. Flap rotating with the blades.
   - c. Flaps on the blades.
   - d. Devices that turn the propeller sideways to the wind.

PATENTED AIR-BRAKE GOVENOR


"Governing" "Normal"

Operates by centrifugal force. When wind velocity exceeds 23 miles per hour, governor flaps automatically open and spread wind away from propeller (See illustration). Governor also acts as a fly wheel to maintain even propeller speed and eliminate vibration in gusty wind.

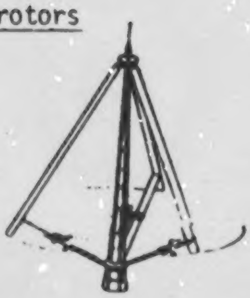


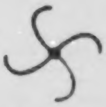
Three-blade wind-driven power plant, with automatic, variable-pitch propeller.

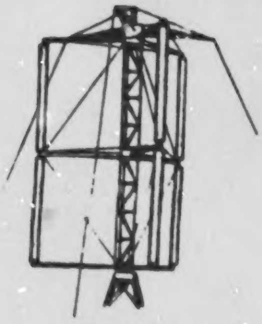
6. Drive, or power output
   - a. Direct coupling to rotor shaft.
   - b. Circular rim attached to blade tips to drive a secondary shaft connected to generator or power output.

1P-3, 1-7

Vertical-axis rotors

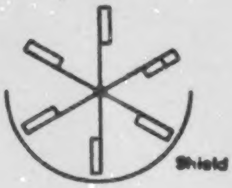

Δ-Darrieus


Multi-Bladed Savonius

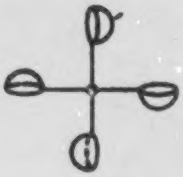

Giromill

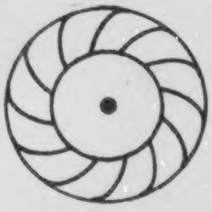
1. Major advantage over horizontal-axis rotors is that they do not have to be turned into the wind as the direction of the wind-stream varies.

2. Those that use plates, cups or turbines are drag devices.



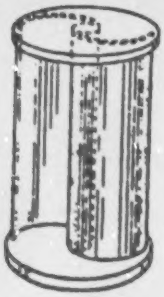
Plates


Cupped


Turbine

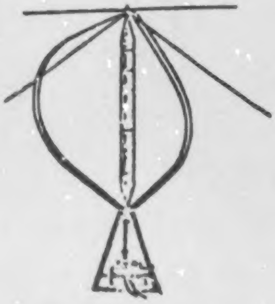
3. Savonius and Darrieus type rotors are lift type devices.

SAVONIUS ROTOR



CHARACTERISTICS:
- Self-Starting
- Low Speed
- Low Efficiency

DARRIEUS ROTOR



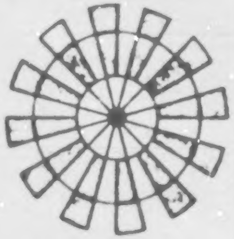
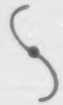
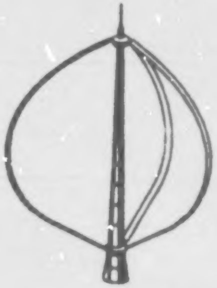
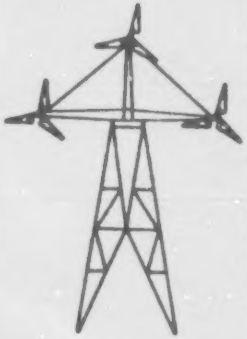
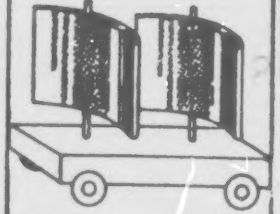
CHARACTERISTICS:
- Not Self-Starting
- High Speed
- High Efficiency
- Potentially Low Capital Cost

INSTRUCTIONAL SHEET IP-3-8

Activity 1

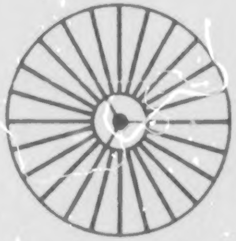
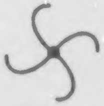
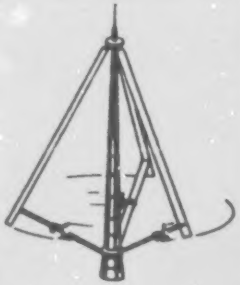
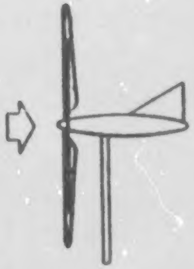
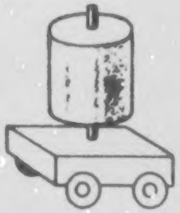
Instructions:

For both groups of descripters in the left hand column place a check mark in the appropriate box below each wind machine that best describes it.

	 U.S. Farm Windmill Multi-Bladed	 Savonius	 ϕ-Darrieus	 Multi-Rotor	 Airfoil
LIFT TYPE					
DRAG TYPE					
COMBINATION					

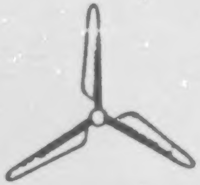
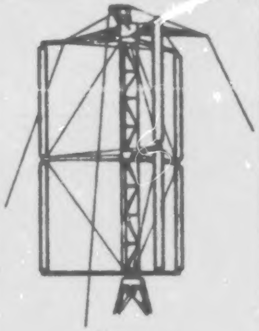
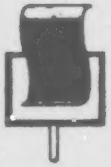
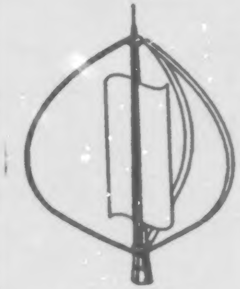
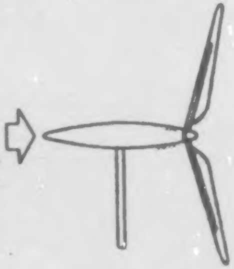
HORIZONTAL AXIS					
VERTICAL AXIS					
TRANSLATIONAL					

IP-3,1-8

	 Bicycle Multi-Bladed	 Multi-Bladed Savonius	 Δ-Darrieus	 Up-Wind	 Magnus
LIFT TYPE					
DRAG TYPE					
COMBINATION					

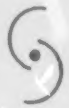
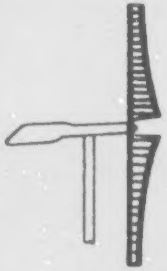
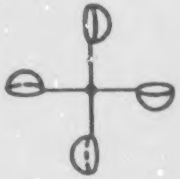
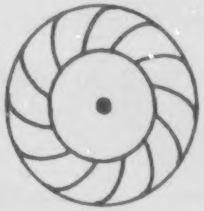
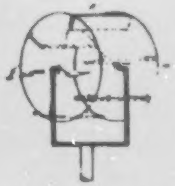
HORIZONTAL AXIS					
VERTICAL AXIS					
TRANSLATIONAL					

IP-3, 1-9

	 Three-Bladed	 Giromill	 Cross-wind Savonius	 Savonius/ϕ-Darrieus	 Down-Wind
LIFT TYPE					
DRAG TYPE					
COMBINATION					

HORIZONTAL AXIS					
VERTICAL AXIS					
TRANSLATIONAL					

10-3, 1-10

	 Split Savonius	 Sail Wing	 Cupped	 Turbine	 Cross-wind Paddles
LIFT TYPE					
DRAG TYPE					
COMBINATION					

HORIZONTAL AXIS					
VERTICAL AXIS					
TRANSLATIONAL					

IP 3,9-11

IP- 3, 1-11

Answers

Activity 1

	Lift	Drag	Combination	Horizontal	Vertical	Translational
U.S. Farm Windmill	X			X		
Savonius		X			X	
Φ-Darrieus	X				X	
Multi-Rotor	X			X		
Airfoil			X			X
Bicycle Multi-Bladed	X			X		
Multi-Bladed Savonius		X			X	
-Darrieus	X				X	
Up-wind	X			X		
Megnus			X			X
Three Bladed	X			X		
Giromill	X				X	
Cross-Wind Savonius		X			X	
Down-Wind	X			X		
Split Savonius			X		X	
Sail Wing	X			X		
Cupped		X			X	
Turbine	X				X	
Cross-Wind Paddles	X			X		

IP- 3, I-13

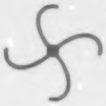
INSTRUCTIONAL SHEET JP-3-13

Activity 2

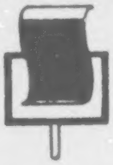
Identify the wind machines shown in the pictures by placing the correct letter from the column of names below each picture in the space provided.

NAMES

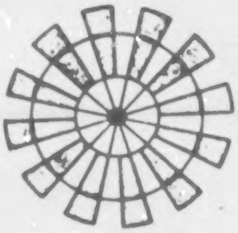
A. U.S. Farm Windmill
B. 0 Darrieus
C. Megnus
D. Turbine
E. Counter rotating blades
F. Giromill
G. Cross-wind savonius
H. Darrieus
I. Airfoil
J. Multi-rotor
K. Savonius
L. Double-bladed



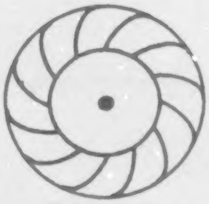
1. ____



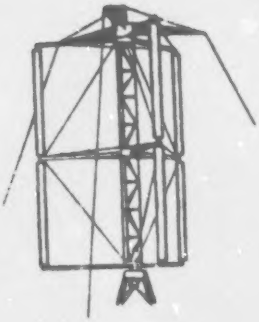
2. ____



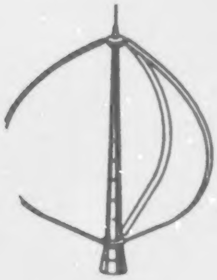
3. ____



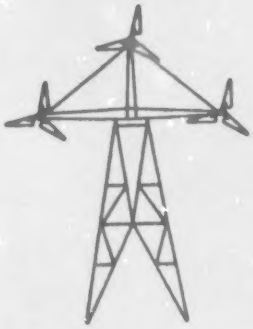
4. ____



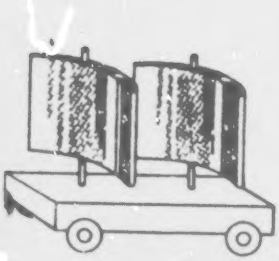
5. ____



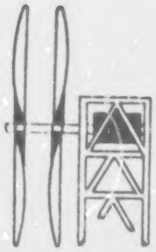
6. ____



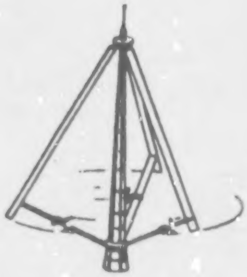
7. ____



8. ____



9. ____

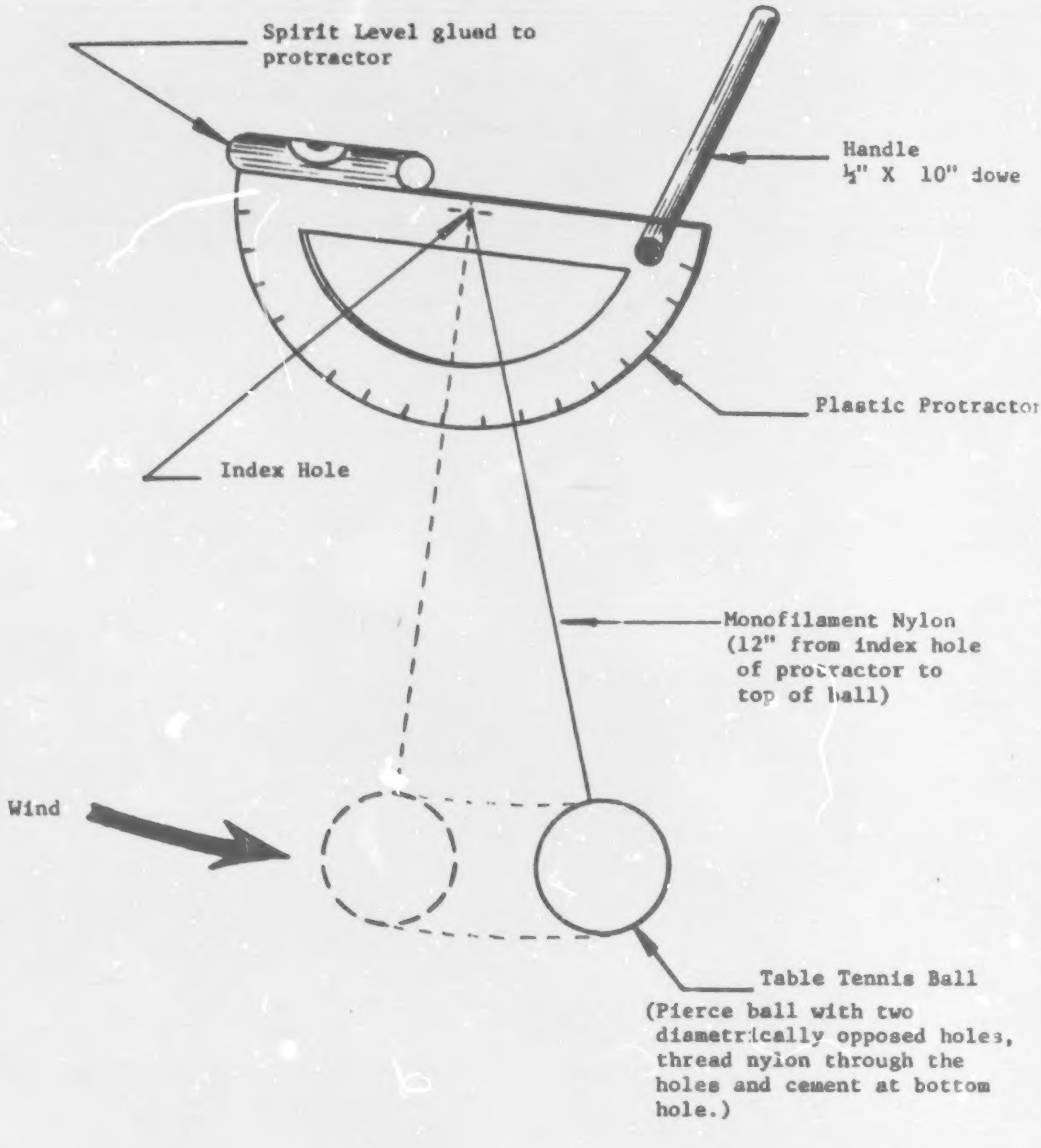


10. ____

INSTRUCTIONAL SHEET IP-3-14

IP-3,1-14

Activity 3


Spirit Level glued to protractor
Handle ½" X 10" dowe
Plastic Protractor
Index Hole
Monofilament Nylon (12" from index hole of protractor to top of ball)
Wind
Table Tennis Ball
(Pierce ball with two diametrically opposed holes, thread nylon through the holes and cement at bottom hole.)

WIND VELOCITY METER
(Anemometer)

Record of Wind Speed Measurement

Activity 4

Measurements taken and recorded by: ______________________

Address where measurements taken: ______________________

Date	Time of Day	Protractor Angle	Wind Speed (mph)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
31			

Angle	Miles Per Hour
90	0
85	5.80
80	8.23
75	10.1
70	11.8
65	13.4
60	14.9
55	16.4
50	18.0
45	19.6
40	21.4
35	23.4
30	25.8
25	28.7
20	32.5

To find the average wind speed add all of the wind speed measurements and divide this total by the total number of observations made. Example: If the total of all wind speed measurements was 330, and this was the result of 30 observations during the month, the average wind speed for that month would be: $\frac{330}{30} = 11$ mph. What is the average wind speed for your area? ________

INSTRUCTIONAL SHEET IP-3-16

Wind Energy Problems

(Activity 5)

1. Write down the two equations concerning wind velocity increase and blade diameter increase. Use them to answer the two following questions.

2. What are the different amounts of power produced by a 5 mph wind, a 10 mph wind and a 15 mph wind, using the same size rotor? Assume that a 5 mph wind produces 10 watts.

3. If the wind was blowing at a constant speed, what differences would there be in the energy production if you switched from a 5 inch rotor to a 10 inch rotor?

FEEDBACK

Objective A - E Check:

Please submit your activity sheets to your instructor for approval

Signature: ______________________________
Instructor

POST-CHECK

ASSESSMENT OF ALTERNATIVE ENERGY SOURCES

1. The most massive experimental windmill was built during

   A. 1940's C. 1960's
   B. 1950's D. 1970's

2. The primary reason for wind energy conversion systems' lack of competition is

   A. cost per KW is too high C. environmentalist opposition
   B. not reliable D. lack of high strength blade metals

3. If the diameter of a rotor blade is doubled, how much does the power increase?

   A. 2 times as much C. 8 times as much
   B. 4 times as much D. doesn't increase at all

4. A general rule might be that the larger the turbine

   A. more blades are needed C. bigger blades are needed
   B. fewer blades are needed D. small blades are needed

5. If the wind speed doubles, how much will power from a wind turbine generator increase:

   A. 2 times as much C. 8 times as much
   B. 4 times as much D. will not increase

6. There are three types of machines with rotors: the horizontal-axis rotor, vertical-axis rotor, and the

   A. translational axis rotor C. cross-wind horizontal axis rotor
   B. yaw active axis rotor D. circular-wind axis rotor

7. The least effective of the three basic types of wind machines with rotors is the

   A. horizontal axis rotor C. cross-wind horizontal axis rotor
   B. vertical axis rotor D. translational axis rotor

8. Savonius and Darrieus type rotors are

   A. drag devices C. horizontal axis devices
   B. translational devices D. lift devices

POST-CHECK (Continued)

9. The major advantage of vertical-axis rotors over horizontal axis rotors is

   A. they do not have to be turned into the wind
   B. they have to be turned into the wind
   C. their wheels have to be mechanically linked to an electric generator
   D. they must be servo controlled

10. Yaw-fixed wind devices

   A. cannot be servo controlled
   B. cannot be rotated into the wind
   C. cannot use a tail-vane
   D. cannot have more than 3 blades

MODULE FIVE

ECONOMIC ASPECTS (COST BENEFIT) OF ENERGY SOURCES

Prepared

by

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USDOE Sponsored Faculty Development Workshop on Energy
Conservation for IAE at North Carolina State University
June 1981 - R.E. Wenig, Director

ECONOMIC ASPECTS (COST BENEFIT) OF ENERGY SOURCES

Our economic system is highly dependent upon an adequate supply of energy. If the energy supply is interrupted, the following economic problems will develop--energy shortages, inflation, unemployment, trade deficits, and the decline in the value of the dollar in world markets.

In this module, you will explore the effects on the economy in choosing energy sources.

TERMINAL PERFORMANCE OBJECTIVE

Analyze the economic aspects of an energy source as it relates to the consumer and producer.

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1.	Recognize Energy Sources	____	____
IP-2.	Describe the Procedure in Computing Capital Outlay for an Energy Source	____	____
IP-3.	Determine Production Cost of an Energy Source	____	____
IP-4.	Explain How Capital Outlay and Production Cost Affect Consumer Prices	____	____
IP-5.	Determine Recovery Cost of an Energy Source	____	____

RESOURCES

All resource information for all instructional packages is included on the resources sheet.

See Resource Sheet.

PRE-CHECK

ECONOMIC ASPECTS (COST BENEFIT) OF ENERGY SOURCES

Directions: Provide the correct response to the individual test items as required in each statement.

IP-1. Recognize Energy Sources

____1. Name three fossil fuels.

A. B. C.

____2. Name three alternative fuels.

A. B. C.

____3. Name the primary source of energy that meets the least percentage of U.S. energy demand.

IP-2. Describe the Procedure in Computing Capital Outlay for an Energy Source

____1. Name three considerations necessary in computing the capital needed to invest in an energy source.

A. B. C.

____2. Write your formula for determining the amount of capital needed for any source of energy.

____3. How does the energy crisis affect capital investments in energy sources?

PRE-CHECK (Continued)

ECONOMIC ASPECTS (COST BENEFIT) OF ENERGY SOURCES

IP-3. Determine Production Cost of an Energy Source

____1. The primary economic problems resulting from ever-increasing oil imports and ever-increasing prices are:

A. Trade Deficit
B. Unemployment
C. Recession
D. Short Supply

____2. According to estimates, at current levels of use, the U.S. has enough coal to last approximately:

A. 50 years
B. 500 years
C. 350 years

____3. What trend is predicted for the U.S. in its use of the world energy source? (Circle correct answer)

A. Smaller percentage
B. Larger percentage
C. Not enough information

IP-4. Explain How Capital Outlay and Production Cost Affect Consumer Prices

____1. Which energy source has the highest capital outlay and production cost?

A. Offshore drilling
B. Nuclear
C. Wind
D. Solar

____2. The amount of oil used in the U.S. as compared to the amount produced is:

A. Only as much as
B. Slightly more than
C. Only half as much
D. Almost twice as much

____3. Ways to dampen the demand for oil could include all but:

A. Rationing
B. Letting prices go up as supplies dwindle
C. Government price controls
D. Tax and price penalties for heavy users

ECONOMIC ASPECTS (COST BENEFIT) OF ENERGY SOURCES

IP-5. Determine Recovery Cost of an Energy Source

____1. What is recovery time as related to any energy source?

____2. Which energy source listed below has the longest recovery time?

A. Electricity
B. Oil
C. Natural Gas
D. Solar

____3. What is the length of time that recovery of an energy source should occur?

PRE-CHECK KEY

IP-1. Recognize Energy Sources

1. Coal, Oil, Natural Gas
2. Solar, Wind, Geothermal
3. Solar

IP-2. Describe the Procedure in Computing Capital Outlay for an Energy Source

1. Net Profit, Labor, Raw Materials
2.
3. Increase in cost limit, greater return over longer period of time

IP-3. Determine Production Cost of an Energy Source

1. A
2. A
3. A

IP-4. Explain How Capital Outlay and Production Cost Affect Consumer Prices

1. B
2. C
3. C

IP-5. Determine Recovery Cost of an Energy Source

1. Time required to cover cost of original investment
2. A
3. 7 years

GENERAL RESOURCES

Listed below are resource materials that can be used for all instructional packages (IP). Other related material may be helpful in the completion of this module.

Books:

Sears Educator Resource Series; Energy/Ecology/Economics. Consumer Information Services, Sears, Roebuck, and Co., P/703, Sears Tower, Chicago, IL 60684

Interdisciplinary Student/Teacher Materials in Energy, the Environment, and the Economy. U.S. Department of Energy, Office of Consumer Affairs, Washington, DC 20595

Comparing Energy Costs. Dr. G. George Reeves, Energy Control System, Raleigh, North Carolina 27606 (Handout included)

Alternative Energy. Dr. F.O. Smetana, Department of Mechanical and Aerospace Engineering, North Carolina State University, Raleigh, North Carolina 27607

Films:

Alternative Energy Sources, Kai Bib Films

ECONOMIC ASPECTS (COST BENEFITS) OF ENERGY SOURCES

IP-1. Recognize Energy Sources

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Recognize energy sources (fossil and alternative fuels)

B. Group energy sources as conventional or alternative sources

RESOURCES

See General Resources

ACTIVITY

A. Review film strip (see General Resources for title) related to energy sources.

B. After reviewing the film strip or reading related information concerning energy sources, find a partner and choose an energy source and discuss its advantages and disadvantages.

C. After the oral presentations in activity B, group the energy sources in the correct table below:

CONVENTIONAL	ALTERNATIVE
1.	1.
2.	2.
3.	3.
4.	4
5.	5.

FEEDBACK

Objective A Check

You should have chosen one of the energy sources below:

1. **Oil**
2. **Coal**
3. Electricity
4. Natural Gas
5. Wood
6. Nuclear
7. Solar
8. Wind (etc.)

Objective B Check:

Conventional	Alternative
1. Oil	1. Nuclear
2. Coal	2. Solar
3. Electricity	3. Wind
4. Natural Gas	4. Oil Shale

____
Instructor's Approval

Have Instructor Sign ________ GO TO NEXT PAGE

ECONOMIC ASPECTS (COST BENEFITS) OF ENERGY SOURCES

IP-2. Describe the Procedure in Computing Capital Outlay for an Energy Source

OBJECTIVE

Upon completion of this instructional package, you will be able to:

A. Describe a procedure for computing capital outlay for an energy source.

B. Find the capital needed to invest in a coal power plant.

RESOURCES

See General Resources

107

ACTIVITY

A. Review handout on comparing energy sources.

B. Using the available resource material, develop a chart displaying some of the components of capital investments for an energy source.

C. In this activity a calculator would be helpful but not necessary.

   a. Determine the amount of capital needed to build a power plant (size 250,000 KW at $1500/KW). Coal is the fuel source.

FEEDBACK

Objective A Check:

You should have listed components similar to the following:

1. Raw Material
2. Labor
3. Net Profit
4. Fuel

Objective B check:

You should have arrived at the following:

($375,000,000.00)

(250,000/Kw x $1,500.00/Kw)

____
Instructor's Approval

Have Instructor sign ________ GO TO NEXT PAGE

IP-3. Determine Production Cost of an Energy Source

OBJECTIVE

Upon completion of this instructional package, you will be able to:

A. Recognize economic problems that can affect production cost.

RESOURCES

See General Resources

ACTIVITY

A. Read resource material concerning economic problems affecting production.

B. After reading material, develop a chart with the production problems included.

FEEDBACK

Objective A Check:

Production problems should have been similar to the problems listed below:

1. Consumer demand (supply and demand)
2. Labor strikes
3. Inflation
4. Unemployment
5. Etc.

Objective B Check:

Included in chart.

____
Instructor's Approval

Have Instructor sign __________ GO TO NEXT PAGE

ECONOMIC ASPECTS (COST BENEFITS) OF ENERGY SOURCES

IP-4. How Does Capital Outlay and Production Cost Affect Consumer Prices

OBJECTIVE

Upon completion of this instructional package, you will be able to:

A. Explain how capital outlay and production cost affect consumer cost of an energy source.

B. Identify energy sources that have high capital investment and production cost.

RESOURCES

See General Resources

111

ACTIVITY

A. With the aid of the resource material or related material, your group will debate the pros of the following topics as related to capital expense and production cost:

1. Offshore drilling versus environmental protection
2. Fuel rationing versus increasing prices to cut demand
3. Benefits of nuclear reactors versus risks.

B. Develop a chart to indicate predicted cost adequacy, technological readiness, environment hazards, future potential for the following sources of energy:

1. Oil shale
2. Solar
3. Nuclear
4. Wind

FEEDBACK

Objective A Check:

Positive participation in the debate.

Objective B Check:

Chart could be similar to the one below:

SOURCE	COST	ADEQUACY OF AVAILABLE SOURCES	HAZARDS
Coal	$40/Ton	Largest non-renewable energy source - U.S.	1. Mining 2. Sulfur 3. Erosion

____
Instructor's Approval

Have Instructor sign ________ GO TO NEXT PAGE

ECONOMIC ASPECTS (COST BENEFITS) OF ENERGY SOURCES

IP-5. Determine Recovery of an Energy Source

OBJECTIVE

Upon completion of this instructional package, you will be able to:

A. Determine the recovery time of an energy source.

RESOURCES

See General Resources

ACTIVITY

Review any up-to-date literature related to energy recover times--as these figures change frequently.

A. Use the chart below as a guide in the solution of this activity - find the recovery time for a solar installation providing 100% of the heat energy. If recovery time is longer than 7 years, the energy source is not economical.

WOOD - ENERGY SOURCE

COST/FUEL	AUXILIARY EQUIP. COST	SAVING FROM INSTALLATION	YEARS NEEDED FOR RECOVERY
Can be 0 if you have free wood --------------	Wood stove or fire place	30% of yearly fuel cost using oil, elec. or gas --------------	Divide savings into investment $\frac{1,210.00}{213.00}$
or use 3-cord, $70 each	500-1,500 avg.	Amount used $59/month	5-6 years to recovery
$210 +	$1000 (1210)	Savings $213/year	

B. Draw a similar chart for solar using the following information:

1. Cost/fuel - $10/Sq.Ft. 600 Sq.Ft. collector space
2. Auxiliary equipment = Cost $3,000.00
3. Yearly electric bill $900.00

FEEDBACK

Objective A Check:

Answer for solar source

Cost/Fuel = $6,000
Aux. & Equip. = 3,000
$9,000

Savings 720.00

Recovery Time $\frac{9,000}{720.00}$ = 12.5 years
(Solar not economical)

____
Instructor's Approval

Have instructor check your work and sign. Ask for Post-Check.

POST-CHECK

ECONOMIC ASPECTS (COST BENEFITS) OF ENERGY SOURCES

DIRECTIONS: Circle the response that best completes each statement.

1. All of the following energy sources are alternative energy sources except:

   A. Oil
   B. Solar
   C. Oil Shale
   D. Geothermal

2. The group using the largest share of U.S. energy is:

   A. Industry
   B. Residential
   C. Transportation
   D. Commercial

3. Disdavantages of solar energy include all but:

   A. Difficulty of storage and transportation
   B. Technology not fully developed
   C. Pollution of air and water
   D. High expense of installation for both new and existing structures

4. The primary economic problem resulting from ever-increasing oil imports and ever-increasing prices is:

   A. Trade deficit
   B. Unemployment
   C. Recession
   D. Short supply

5. In American homes, the greatest amount of energy is used for:

   A. Lighting
   B. Heating and cooling
   C. Electric appliances
   D. Gas appliances

6. Fuel conservation by consumers for their homes and cars causes fewer economic problems than conservation by business and industry because:

   A. Consumers make up the least important sector of the economy. B.
   B. Consumers waste more energy than other fuel users.
   C. Larger energy cutback by business and industry would result in fewer jobs and lower productivity.
   D. Consumers use more energy than business and industry.

7. Which energy source has the longest recovery time?

   A. Coal
   B. Solar
   C. Oil
   D. Nuclear

POST-CHECK (Continued)

ECONOMIC ASPECTS (COST BENEFITS) OF ENERGY SOURCES

8. Fossil fuels include all except:

A. Coal	C. Oil
B. Natural Gas	D. Wood

9. The disadvantage of turning to nuclear energy as an alternative to fuel oil include all but:

   A. high cost of developing and building breeder reactors
   B. high levels of radioactive waste
   C. inefficiency of nuclear fuel
   D. the plutonium by-product which is used for atomic bombs must be isolated and protected from theft.

10. Which energy source listed below has a better recovery time?

A. Wood	C. Wind
B. Solar	D. Oil Shale

POST-CHECK KEY

ECONOMIC ASPECTS (COST BENEFITS) OF ENERGY SOURCES

1. A
2. B
3. A
4. A
5. B
6. D
7. D
8. D
9. C
10. A

MODULE SIX

CONSERVING ENERGY THROUGH CHANGES IN HABITS, ATTITUDES, AND GAINING SELF-SUFFICIENCY

Prepared

by

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USDOE Sponsored Faculty Development Workshop on Energy
Conservation for IAE at North Carolina State University
June 1981 - R.E. Wenig, Director

CONSERVING ENERGY THROUGH CHANGES IN HABITS, ATTITUDES, AND GAINING SELF-SUFFICIENCY

TERMINAL PERFORMANCE OBJECTIVE

After completion of this module, the student will, through a written evaluation (post-check) at an 80% competency level, demonstrate a change in attitude awareness toward gaining self-sufficiency.

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1.	Developing a Personal Awareness of Conflicts Between Energy Conservation Values	____	____
IP-2.	Developing Positive Attitudes Toward Energy Conservation Through Changes in Home Energy Use	____	____
IP-3.	Developing a Positive Attitude Toward Energy Conservation Through Changes in Transportation Habits	____	____

PRE-CHECK

CONSERVING ENERGY THROUGH CHANGES IN HABITS, ATTITUDES, AND GAINING SELF-SUFFICIENCY

Directions: Mark "T" if the statement is true. If the statement is false, mark "F."

IP-1. Developing a Personal Awareness of Conflicts Between Energy Conservation Values

____1. The world's supply of oil is an inexhaustible resource for producing gasoline in the U.S.

____2. Because of the recent construction of nuclear power plants, we have all the electricity we will ever need.

____3. The energy cost for an automobile is over 40% of the total energy requirements in the home of an average American family.

____4. Central heating requires very little energy as compared to other energy users in the average American home.

____5. From 1960 until 1972, the number of American cars with air conditioning rose from 7% to 69%.

____6. Upper income families use over five (5) times as much gasoline as lower income families.

IP-2. Developing Positive Attitudes Toward Energy Conservation Through Changes in Home Energy Use

____1. A heat pump uses thermal energy from outside air for both heating and cooling.

____2. To conserve energy in the winter, thermostats should be set at 60° F.

____3. During the winter months, close window drapes at night and open during the day.

____4. The most efficient lighting is flourescent.

____5. Incandescent lights should be turned off each time you leave the room.

____6. When using air conditioning, set your thermostat at 72° F.

____7. The average dishwasher uses 14 gallons of hot water per load.

____8. Wash clothes in cold water and rinse in warm.

PRE-CHECK (Continued)

CONSERVING ENERGY THROUGH CHANGES IN HABITS, ATTITUDES, AND GAINING SELF-SUFFICIENCY

IP-3. Developing a Positive Attitude Toward Energy Conservation Through Changes in Transportation Habits

____1. Driving at 55 mph uses less gasoline than driving at 70 mph.

____2. When coming to a stop sign, a quick stop helps save gasoline.

____3. Cars account for nearly 40% of the oil used in this country.

____4. It takes less gasoline to restart the car than it takes to let it idle for one minute.

____5. Radial tires can improve gasoline mileage on the highway by about 15%.

____6. A poorly tuned car could use as much as 25% more gasoline than a well-tuned one.

____7. The average occupancy per commuter car is 1.3 people.

____8. For every 100 pounds of extra weight, fuel economy is reduced by about 5% for the average car.

PRE-CHECK KEY

IP-1. Developing a Personal Awareness of Conflicts Between Energy Conservation Values

1. F
2. F
3. T
4. F
5. T
6. T

IP-2. Developing Positive Attitudes Toward Energy Conservation Through Changes in Home Energy Use

1. T
2. F
3. T
4. T
5. T
6. F
7. T
8. F

IP-3. Developing a Positive Attitude Toward Energy Conservation Through Changes in Transportation Habits

1. T
2. F
3. T
4. T
5. F
6. T
7. T
8. F

CONSERVING ENERGY THROUGH CHANGES IN HABITS, ATTITUDES, AND GAINING SELF-SUFFICIENCY

IP-1. Developing a Personal Awareness of Conflicts Between Energy Conservation Values

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Examine their values and beliefs about energy consumption and conservation through completion of an energy questionnaire.

RESOURCES

Books:

Ideas and Activities for Teaching Energy Conservation: Grades 7-12. Tennessee Energy Office, Tennessee State Department of Education, 1977.

Energy Conservation Resources for Education. Texas A&M University, Department of Industrial Education, College Station, Texas.

Magazines:

"Changing Our Energy Behavior." Hogan, M.J. Journal of Home Economics, May 1978.

ACTIVITY

Complete the following energy questionnaire (Instructional Sheet IP-1-1-2) and list as many reasons as possible to substantiate your opinions or beliefs for each statement. Research on energy for this activity may be obtained from the listed resources or other appropriate references.

FEEDBACK

Objective Check:

Students should know how an opinion can affect their behavior or lifestyles. Where they are uncertain about their opinion, they should conduct sufficient research to uphold an opinion when asked to defend their positions in class.

Instructional Sheet IP-1-1-2 from Ideas and Activities for Teaching Energy Conservation: Grades 7-12. Tennessee Energy Office of State Department of Education, 1977, pp. 149-150.

Instruction Sheet IP-1-1

ENERGY OPINIONAIRE

Name ______________________________ Date ____________________

Class ______________________________ Teacher ____________________

Directions: Please cross out the word or phrase within the parentheses which least indicates your opinion. Be prepared to defend your opinion or belief.

I believe that:

1. The energy resources in the United States (are, are not) controlled by monopolies.
2. There (is, is not) a shortage of oil in our country.
3. We (should, should not) generate more energy by nuclear and fossil fuels.
4. Solar energy technology for generating electricity (is, is not) well established at this time.
5. Government funds (should, should not) be used to develop the railroads and barge traffic.
6. If fuel prices were to decline, consumption (would, would not) greatly increase.
7. American lifestyles (are, are not) wasteful of energy.
8. Manufacturers (should, should not) be forced to reveal the energy costs of their products.
9. Nonreturnable and disposable containers (should, should not) be discontinued.
10. Rising energy costs (have, do not have) a direct, personal impact on everyone.
11. Everyone (should, should not) observe reduced speed limits to conserve energy.
12. The use of energy (is, is not) a moral problem involving stewardship of resources.
13. The government (should, should not) restrict the size of cars.
14. The cost of pollution control (should, should not) be included in the individual customer's bill.

Instructional Sheet IP-1-2

15. An individual (can, cannot) have an impact on energy consumption.

16. Individuals (will, will not) conserve energy if they realize there is a problem.

17. We (should, should not) develop energy resources regardless of environmental costs.

18. All demands for energy (will, will not) be met in the year 2000.

19. People (are, are not) born greedy and selfish in respect to use of natural resources.

20. Strict federal laws (will, will not) be the major factor in energy consumption.

21. Nuclear power (is, is not) too dangerous to be used in producing electricity.

22. Our government (is, is not) being effective in solving our energy problems.

23. Everyone (should, should not) be required to pay for energy regardless of economic level.

24. The production of an adequate supply of energy (is, is not) a major problem in our country today.

25. The energy problem (is, is not) political rather than technological.

26. The average citizen (is, is not) getting honest information on energy problems and their solutions.

27. Energy production (should, should not) be controlled by government rather than private industry.

28. Alternative energy sources such as wind, geothermal, solar, and tidal power (are, are not) receiving adequate funds for their development.

29. Foreign countries (do, do not) have the right to charge any price they please for their natural resources.

30. My family (is, is not) doing an adequate job of conserving energy.

6

CONSERVING ENERGY THROUGH CHANGES IN HABITS, ATTITUDES, AND GAINING SELF-SUFFICIENCY

IP-2. Developing Positive Attitudes Toward Energy Conservation Through Changes in Home Energy Use

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Compile a list of all energy consuming device in his home and compare the average energy consumption of each device.

B. Record and compute the average daily electric consumption of a conventional home over a one-week period and compare the findings with those results recorded for a similar time span of concentrated energy conservation for the same home.

C. Build a watt-meter to compare the individual differences in energy consumption of various small appliances.

D. Develop a list of energy saving techniques to apply in his home during eac season of the year.

RESOURCES

Books:

Energy Conservation Resources for Education. Texas A&M University, Department of Industrial Education, College Station, Texas: 1978, pp. 151-158.

Ideas and Activities for Teaching Energy Conservation: Grades 7-12. Tennessee Energy Office of State Department of Education. 1977, pp. 190-191.

Providing for Energy Efficiency in Homes and Small Buildings. U.S. Department of Energy. Office of Consumer Affairs, Education Division: Washington, DC, June 1980, Part I pp. 47-48, 78-83.

Tips for Energy Savers. U.S. Department of Energy. Washington, DC, pp. 1-39.

Instructional Sheet: IP-2A-1-2 Monthly Energy Requirements of Electric Household Appliances

Instructional Sheet: IP-2B-1-2 How Much Electricity Does it Use

ACTIVITY

A. Compile a list of all electric energy consuming devices in a conventional home and determine the approximate KWH/yr. and the cost required to use each appliance for one year. Refer to handout of "Monthly Energy Requirements of Electric Household Appliances" from Carolina Power & Light, Raleigh, NC. Instructional Sheet IP-1-1-2

B. Read the watt-meter of a conventional home at the same time every 24 hours for 7 days. Record these readings on a bar graph. Compute the total weekly electrical consumption and figure the average daily consumption of one week. Reference: Energy Conservation Resources for Education, pp. 151-156

C. Build the watt-meter test board as diagrammed on the handout. Using the test board, measure the amount of energy consumed by a variety of small appliances over a specified time and record. (See Figure 2.) Reference: How Much Electricity Does It Use?, pp. 32.

D. Compile a list of energy saving techniques to be utilized in a conventional home for each of the following areas.

Heating
Air Conditioning
Hot Water
Dish Washer
Refrigerators and Freezers
Ovens and Stoves
Clothes Washers and Dryers

References: 100 Ways to Save Energy, Providing for Energy Efficiency in Homes and Small Buildings p. 78-83, and Tips for Energy Savers.

FEEDBACK

Objective A Check:

From the information obtained in Activity A, figure the approximate percentage of total energy used in a month's time that is consumed by each of the following:

Heating
Lighting
Air Conditioning
Refrigeration
Cooking
Hot Water
Miscellaneous

FEEDBACK (Continued)

Objective B and C Check:

Read the dials of the watt-hour meter gauge and write the correct number on the blanks provided. (See Figure 2)

Objective D Check:

Utilizing the energy saving techniques developed in Activity D and other information obtained from previous activities, figure the energy savings that would result from a conscious change in habits and attitudes through the following activity.

> Record and compute the daily electrical consumption for the same house as in Activity D over the same period of time while making a conscious effort to utilize the energy saving techniques developed in Activity D. Compare these results with the findings in Activity B. Even though this difference may be small, the computed savings over a long period of time should be significant.

1P-2A,1

MONTHLY ENERGY REQUIREMENTS OF ELECTRIC HOUSEHOLD APPLIANCES

APPLIANCES	TYPICAL WATTAGE	APPROX. OPERATING COST PER HOUR	APPROX. KWH USED PER MONTH	APPROX. MONTHLY COST
Air Conditioner (Window) 12 Hrs. Use - 6,000 BTU 115 Volt	860	4.3¢	310	$ 15.50
12 Hrs. Use - 12,000 BTU 230 Volt	1,950	9.8¢	702	$ 35.10
Electric Blanket (8 Hrs. use per day)	190	8.0¢/day	46	$ 2.30
Broiler	1,500	7.5¢		
Clock	2		1.5	7.5¢
Clothes Dryer (55 min. cycle) 7 loads/week ($5.37/Month)	5,500	27.5¢/load		
"Crock-Pot"	70/140	.6¢		
Coffee Maker	1,000	5.0¢		
Compactor	1,380		3	15.0¢
Deep Fryer	1,620	8.1¢		
Dehumidifier 24 hrs. use 22 pts./day	600		14.4/day	72.0¢/day
Dishwasher Including hot water 32 loads/month	800	16.0¢/load	102	$ 5.10
Dripping Faucet - slow			40	$ 2.00
Dripping Faucet - medium			80	$ 4.00
Dripping Faucet - fast			120	$ 6.00
Fan (Attic)	370	1.8¢		
Fan (Circulating) 10 hrs. use/day	88	4.4¢/day		
Burner & Fan (furnace-oil) 6 months use-1375 hours	836		192	$ 9.60
Fan (Roll-about)	171	0.9¢		
Fan (Window)	200	1.0¢		
Food Mixer	127	0.6¢		
Food Waste Disposer	445		2.5	12.5¢
Frying Pan	1,600	7.9¢		
Hair Dryer (soft bonnet)	400	2.1¢		
Hair Dryer (hard bonnet)	900	4.5¢		
Hair Dryer (hand held)	600	2.9¢		
Heater (radiant)	1,650	8.2¢		
Hot Plate	1,650	8.2¢		
Humidifier - 6 hrs./day	115	5.0¢	21	$ 1.05
Iron (hand)	1,000	5.0¢		
Lamps, Fluorescent (6 hrs./day) 40 watt 48" (inc. ballast)	50		9	45.0¢
(6 hrs./day) 80 watt 96" (inc. ballast)	100		18	90.0¢
Lamps, Incandescent 60 watt size (6 hrs./day use)	60		11	55.0¢
100 watt size (6 hrs/day use)	100		18	90.0¢
Microwave Oven 15 min. per day use	1,460	7.3¢	11	55.0¢

1 P-2A, 2

Radio	75	3.7¢/10 hrs.		
Radio-Phonograph-Stereo	125	6.3¢/10 hrs.		
Range	12,000		110	$ 5.50
Refrigerator				
Side-by-side, no frost				
22 cu. ft.	495		180	$ 9.00
22 cu. ft./customer dispenser	495		186	$ 9.30
Refrigerator				
2 door (top mount) no frost				
21 cu. ft.	475		167	$ 8.35
18 cu. ft.	475		165	$ 8.25
16 cu. ft.	475		138	$ 6.90
14 cu. ft.	475		129	$ 6.45
Refrigerator				
2 door (top mount) cycle defrost				
14 cu. ft.	475		110	$ 5.50
12 cu. ft.	475		97	$ 4.85
Refrigerator				
Single-door, manual defrost - 10 cu. ft.	300		58	$ 2.90
Food Freezer				
No frost upright				
16 cu. ft.	475		210	$ 10.50
Food Freezer				
Upright, manual defrost				
15 cu. ft.	475		155	$ 7.75
12 cu. ft.	440		137	$ 6.85
Food Freezer				
Chest, manual defrost				
20 cu. ft.	400		140	$ 7.00
15 cu. ft.	400		119	$ 5.95
Sun Lamp	150	0.8¢		
	300	1.5¢		
Television (B&W) (8 hrs. per day)	150	0.8¢	36	$ 1.80
Television (Color) (8 hrs. per day)	300	1.5¢	72	$ 3.60
Television				
Instant On when "off"				
B&W (Solid State)	13		9	45.0¢
Color (Solid State)	16		11	55.0¢
Toaster	1,320	6.5¢		
Toaster Oven	1,500	7.7¢	14	70.0¢
Vacuum Cleaner	920	4.6¢	6.0	30.0¢
Waffle Iron	1,200	6.0¢	1.2	6.0¢
Washing Machine Only	300	1.5¢/Load	10	50.0¢
Washing Machine				
Hot wash warm rinse includes cost of hot water based on 30 gallons of hot water per wash	300	43.6¢/Load	263	30 Loads/Mo. $ 13.15
(58 minute cycle)				
Water Heater (4 in family)	4,500		409	$ 20.45
Water Pump	460		75	$ 3.75

NOTE: Cost figures are based on 5.0¢ KWH. These cost figures do not reflect the basic customer charge for residential customers.

1P-2B,1

How Much Electricity Does It Use?

By Peter Vignogna

To help students understand the impact various appliances have on electricity bills, I designed an instrument for determining the exact cost of using any 110 V electrical device. "Project Kilowatt" can be constructed in a few hours, once the parts have been obtained. Most utility companies will donate a used wattmeter, which is the most expensive component needed for the project.

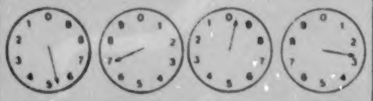
The method. First, record a reading of the kilowatt meter, and connect the "Project Kilowatt" board to a 110 V outlet. Then, plug the electrical device to be tested into the outlet mounted on the board, and turn on the switch. Power is now fed through the wattmeter into the appliance. After a specific time, turn off the power and record the wattmeter reading. The difference between this reading and the first reading is the amount of kilowatt hours consumed by the device. Compute the cost by multiplying the rate per kilowatt hour by the number of kilowatt hours consumed. Get the rate from an electric bill or by calling the utility company. □

Peter Vignogna is chairman of the industrial arts department, Marcellus (New York) Senior High School.

Reading the meter

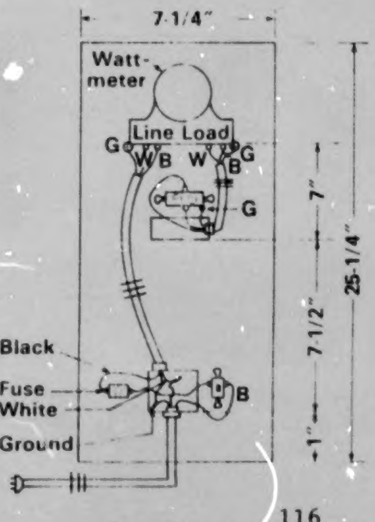
1. Read the meter dials from left to right.
2. Read the dials as thousands, hundreds, tens, and units.
3. If a pointer seems to be exactly over a number, check if the pointer on the dial to the right is on or past zero. If it isn't, use the lower of the two numbers.
4. Answer is as read in kilowatt hours.

The dials below indicate 5,692 kilowatt hours.



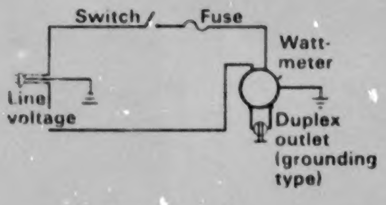
PARTS LIST

- 3/4 × 7-1/4 × 25-1/4 pine baseboard
- Watthour meter
- Duplex outlet (grounding type) and outlet box
- 4″ metal box for fuse holder and switch (Fusetron type SSY)
- 15 A plug fuse
- 12 or 14 ga. cable, two-wire with ground
- Line cord, three-wire type
- 3 cable connectors
- Wire nuts



Board layout

After building the "Project Kilowatt" boards, students can take them home and apply what they have learned to their families' electrical needs.



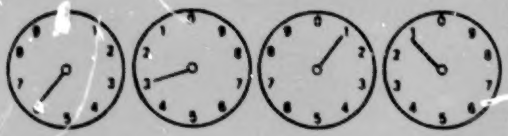
Circuit design

BEST COPY AVAILABLE

1P-2B,2

Read the dials and write the correct numbers on the blanks provided.

1



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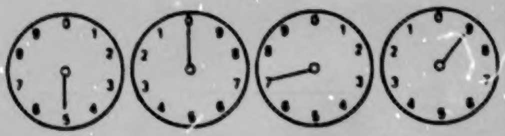
2



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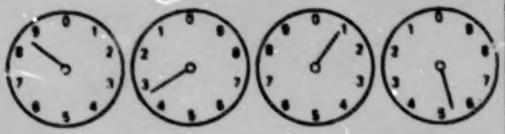

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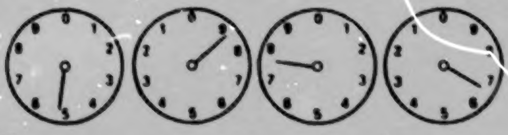

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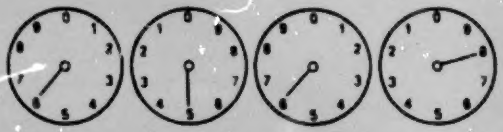
5



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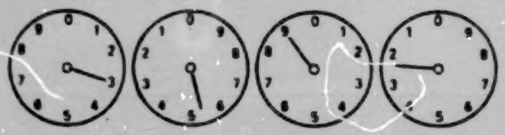
6



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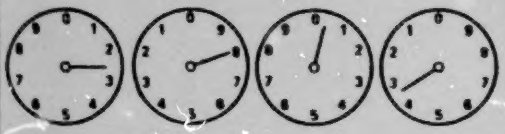
7



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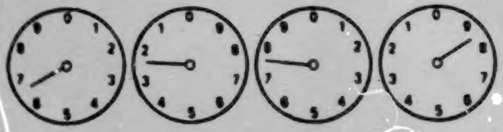

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CONSERVING ENERGY THROUGH CHANGES IN HABITS, ATTITUDES, AND GAINING SELF-SUFFICIENCY

IP-3. Developing a Positive Attitude Toward Energy Conservation Through Changes In Transportation Habits

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Perform an energy analysis of his transportation habits and attitudes to determine areas where habits may be modified to conserve energy.

B. List energy saving steps that can be utilized when driving an automobile.

C. Determine the energy savings gained through a conscious change in driving habits.

D. Develop an energy conservation program based on modification of his personal transportation habits and behavior.

RESOURCES

Books:

Energy Conservation Resources for Education. Texas A&M University, Department of Industrial Education. College Station, Texas, pp. 234-264.

How a Bill Becomes a Law to Conserve Energy. U.S. Department of Energy. Consumer Affairs: Washington, DC. April 1980, pp. 45-58.

Ideas and Activities for Teaching Energy Conservation: Grades 7-12. Tennessee Energy Office of State Department of Education, 1977, pp. 149-150.

Tips for Energy Savers. U.S. Department of Energy. Washington, DC, pp. 1-25.

Magazines:

"Changing our Energy Behavior." Hogan, M.J. Journal of Home Economics, May 1978, pp. 18-21.

"Energy Conservation in Davis, California." Jolly, D. and K. Giter. Journal of Home Economics, May 1978, pp. 37-38.

"100 Ways to Save Energy." Stewart, M.S. and W.D. Moss. Journal of Home Economics, May 1978, pp. 36.

ACTIVITY

A. Maintain a record of transportation for a 2-week period, recording the following information:

Method of Transportation Used
Number of Trips
Reason for Trips
Distance Traveled
Number of Persons Traveling Together
Total Amount of Fuel Used
Total Cost of Fuel
Average Miles Per Gallon (MPG) at end of 2 wee period

At end of the two (2) week period, discuss the results and how energy could have been saved by modifying habits, behavior, attitude, methods of transportation, etc.

B. Compile a list of energy saving techniques that can be applied through various means of transportation. Consider the automobile as the primary means of transportation and the conservation steps that can be taken that involve driving habits, preventive maintenance, etc. Discuss your list and the advantages and disadvantages of each energy saving technique.
Reference: Changing Our Energy Behavior, How a Bill Becomes a Law, 100 Ways to Save Energy, and Tips for Energy Savers

C. Using the carpooling activity sheet furnished, figure the costs of commuting to and from school. Discuss these results. (See Instructional Sheet IP-3A1-3.)
References: Ideas and Activities for Teaching Energy Conservation: Grades 7-12 and Energy Conservation Resources for Education.

D. Utilizing the energy saving techniques compiled in Activity B to the fullest extent, maintain a record of transportation for a two-week period, recording the same information as for Activity A. Make a comparison of the results with those in Activity A and discuss the findings. Consider whether a change in transportation habits would be cost effective for the long and short term. Discuss how behavior changes would affect your lifestyle regarding transportation.
Reference: Changing Our Energy Behavior

FEEDBACK

A. Considering each of the following points and utilizing discussion of the previous activities, develop an energy plan for conserving energy through transportation. (See Instructional Package IP-3 Feedback)

B. Write a scenario or future history of what your life would be like if you were limited to 8 gallons of gasoline per month. How would your lifestyle be affected? What changes do you think would have to be made in our society? What changes in behavior would you have to make? Would this affect how and where you would live or the types of transportation you would use?

Instructional Sheet IP-3A1-1

Using the following information, figure the cost of commuting to and from school:

Car Size	Vehicle Cost Depreciated	Maintenance Accessories, Parts & Tires	Gas & Oil (Excluding Taxes)	Insurance	State and Federal Taxes	Total Cost (Per Mile)
Standard	4.5¢	3.7¢	5.5¢	1.7¢	1.6¢	= 17¢
Intermed.	4.2¢	3.4¢	5.3¢	1.6¢	1.5¢	= 16¢
Compact	2.9¢	2.7¢	4.7¢	1.5¢	1.2¢	= 13¢
Subcompact	2.3¢	2.5¢	3.8¢	1.5¢	0.9¢	= 11¢

Adapted from U.S. Department of Transportation-Federal Highway Administration Statistics

Example - How to figure your present commuting cost (Standard car=Ford LTD) traveling 30 miles round trip

1. MULTIPLY (.17) x (30) = $5.10
   Cost per mile   Miles per day

2. ADD Daily parking cost +0

3. TOTAL DAILY COST = $5.10

4. MULTIPLY DAILY COST By number of school days per month x21

5. COST PER MONTH TO DRIVE ALONE = $107.10

6. DIVIDE BY NUMBER OF PEOPLE IN CARPOOL ÷ 4

7. NEW INDIVIDUAL COST BY CARPOOLING = $26.77

8. MONTHLY CARPOOL SAVING ($107.10 - 26.77)$80.33

*IMPORTANT - For a successful carpool when the driver-owner does all the driving fair share rates should be figured on paying riders only. The driver-owner should ride free.

Instructional Sheet IP-3B1-2

1. MULTIPLY ______ x ______ = $__________
   Cost Per Mile   Miles Per Day

2. ADD Daily Parking Cost __________

3. TOTAL DAILY COST = __________

4. MULTIPLY DAILY COST
   By number of school days per month X __________

5. COST PER MONTH TO DRIVE ALONE = __________

6. DIVIDE BY NUMBER OF PEOPLE IN CARPOOL ÷ __________

7. NEW INDIVIDUAL COST BY CARPOOLING = __________

8. MONTLY CARPOOL SAVING (#5-#7) = __________

CONTACT ORGANIZATIONS:

1. Transportation Research Center, The University of Tennessee, South Stadium Hall, Knoxville, Tennessee 37916.

2. Tennessee Energy Office, Suite 250, Capitol Hill Building, 7th and Union Nashville, Tennessee 37219.

3. U.S. Department of Transportation, 400 Seventh Street, SW, Washington, DC 20590

4. Tennessee Department of Transportation, 817 Highway Building, Nashville, Tennessee 37219.

Instructional Sheet IP-3 Feedback 1-3

It is said that Americans travel farther and faster than any other people in the world. Transportation (fuel, manufacturing and maintenance, highways) accounts for about 42% of our total energy budget in the United States. Thereis great potential for saving energy in the transportation sector.

Have students conduct research and contact organizations to learn more about conserving energy through transportation. As a result of their research, they should prepare a plan for themselves and their families. In conducting research, students should consider the following points:

1. Methods of making vehicles more energy-efficient.
2. Methods of saving energy in manufacturing and maintaining vehicles.
3. Methods of saving energy in road construction and maintenance.
4. Driving habits which result in energy conservation (e.g., fewer rapid accelerations, less quick braking).
5. Kinds of energy conservation legislation to mandate or encourage energy conservation through transportation (e.g., 55 mph speed limit, right-turn-on-red-after-stop).
6. Requirement of pollution control devices.
7. Advantages/disadvantages of radial tires, ignition systems, streamlining designs, increasing passengers per vehicle, abandoning automatic transmissions.
8. Salvaging metals, etc., from junked vehicles.
9. Unnecessary trips or travel.
10. Ways to conserve energy while on vacation.
11. Growth, decline, advantages, and disadvantages of travel by walking, bicycle, automobile, bus, railroad, water, airplane.
12. Alternatives to individual transportation: carpools, vanpools, mass transit.

Figure 4 Energy: Plan for Conserving (Adopted from Ideas and Activities for Energy Conservation: Grades 7-12, Tennessee Energy Office).

POST-CHECK

CONSERVING ENERGY THROUGH CHANGES IN HABITS, ATTITUDES, AND GAINING SELF-SUFFICIENCY

Directions: Circle letter representing correct answer.

1. With regard to energy, the nation must:

   A. Conserve energy
   B. Develop alternate sources of energy
   C. Slow down the acleration in new demands for energy
   D. All of the above.

2. The chief concern of the individual is:

   A. Developing alternate sources of energy
   B. Conserving energy
   C. Repair and maintenance

3. To conserve energy in winter, set thermostat at:

   A. 68° F   C. 68° F day, and 69° F night
   B. 60° F

4. To conserve energy in summer, set thermostat at:

   A. 78° F   c. 68° F
   B. 72° F

5. Keep window drapes exposed to sun during winter:

   A. Drawn at night, open during the day
   B. Open during the night, drawn during the day
   C. Open all the time

6. Window drapes exposed to sun during summer are:

   A. Open during the day
   B. Drawn during the day
   C. Closed all the time

7. To conserve energy:

   A. Operate furnace at full capacity at all times
   B. Heat 1/2 the building at a time.
   C. Heat only rooms that are being used

8. When using a fireplace:

   A. Keep windows open
   B. Keep damper closed
   C. Provide outside air to fire box if possible

POST-CHECK (continued)

CONSERVING ENERGY THROUGH CHANGES IN HABITS, ATTITUDES, AND GAINING SELF-SUFFICIENCY

9. Attic ventilators are used to:

   A. Supplement the air conditioning
   B. Reduce the temperature in the attic
   C. Provide for higher temperatures

10. Air conditioner vents should be adjusted:

    A. Upward
    B. Downward

11. The heating system is aided by lighting.

    A. True
    B. False

12. Kitchen and bathroom vent fans should be operated:

    A. Continually
    B. Intermittently
    C. Only when needed

13. Air conditioners should be operated:

    A. Continually
    B. Intermittently
    C. Only when needed

14. The difference in energy use with the air conditioner set at 78° F instead of 72° F would be:

    A. 40%
    B. 10%
    C. 60%

15. The most efficient lighting is:

    A. Incandescent
    B. Flourescent
    C. Same

16. Ways to save lighting energy are to:

    A. Use dimmer switches
    B. Use lower watt bulbs
    C. Turn lights off when not in use
    D. All of the above

17. Incandescent lights should be turned off:

    A. Each time you leave the room
    B. If you are going to be gone for at least 15 minutes

18. Flourescent lights should be turned off:

    A. Each time you leave the room
    B. If you are going to be gone for at least 15 minutes

POST-CHECK (continued)

CONSERVING ENERGY THROUGH CHANGES IN HABITS, ATTITUDES, AND GAINING SELF-SUFFICIENCY

19. Refrigerator doors should be opened:

A. All the way C. Remain closed
B. As infrequently as possible

20. Place hot dishes in the refrigerator:

A. Immediately C. Gradually
B. Only after they have cooled

21. Use dishwasher:

A. As often as you have dirty dishes C. To wash glasses only
B. Only when you have a load

22. When baking:

A. Try to fill the oven
B. Cook one panful at a time
C. Leave the oven door cracked open for ventilation

23. When boiling water:

A. Leave the pot open C. Use a baking dish
B. Keep a lid on the pot

24. When cooking frozen foods:

A. Allow them to thaw or partially thaw before cooking
B. Cook them immediately after removing from the freezer
C. Keep them in the original container.

25. Microwave ovens are:

A. Good for frying foods C. Low in proteins
B. More efficient than infrared ovens

26. Aluminum pots are the most efficient.

A. True B. False

27. Aluminum foil is recommended to line:

A. The oven
B. The reflector pans under electric burners

POST-CHECK (continued)

CONSERVING ENERGY THROUGH CHANGES IN HABITS, ATTITUDES, AND GAINING SELF-SUFFICIENCY

28. When washing clothes:

A. Use hot water　B. Use cold water　C. Use salt water

29. Dry clothes:

A. As rapidly as possible
B. Only until dry
C. Past the drying cycle to reduce wrinkles

30. Energy can be saved:

A. At home　D. In hospitals and schools B. In
public buildings　E. All of the above
C. In office buildings

31. Whose responsibility is it to save energy at school?

A. The teachers　C. The building superintendent B.
The students　D. All of the above

32. The same rules for conserving energy in the home generally apply to other buildings.

A. True　B. False

33. Energy surveys are:

A. Important　B. A waste of time　C. Expensive

34. The best procedure for energy saving in buildings is to:

A. Assign responsibilities
B. Let everyone decide what to do
C. Turn the lights out when not in use

35. The design and maintenance of public buildings are:

A. Important to energy saving
B. Not important
C. Always done with energy efficiency in mind

36. A planned use of buildings can contribute to energy efficiency.

A. True　B. False

CONSERVING ENERGY THROUGH CHANGES IN HABITS, ATTITUDES, AND GAINING SELF-SUFFICIENCY

37. When providing food service in buildings:

    A. It is best to cater food
    B. Efficiency measures are similar to those for the home
    C. Cook only one meal per day

38. When coming to a stop sign in an automobile, one should:

    A. Brake quickly C. Put the car in neutral
    B. Anticipate and brake slowly

39. When stopped and idling for more than a minute, one should:

    A. Turn off engine C. Continue to idle in neutral
    B. Continue to idle as slow as possible

40. Driving at 55 mph uses less gasoline than driving at:

    A. 35 mph C. 70 mph
    B. 50 mph

41. A poorly tuned car could use as much as __ percent more gasoline than a well-tuned one.

    A. 3 to 9 C. 25
    B. 10 to 20

42. Radial tires can improve gas mileage on the highway about:

    A. 3% B. 7% C. 15%

43. Underinflated tires can reduce fuel economy about _____ for every pound of pressure under the recommended pounds per square inch.

    A. 2% b. 5% C. 10%

44. For every 100 pounds of extra weight, fuel economy is reduced about ___ for the average car.

    A. 1% B. 3% C. 5%

45. When buying a car, a decision should be based on:

    A. Price of the car C. Both A and B
    C. Estimated fuel cost

POST-CHECK (continued)

CONSERVING ENERGY THROUGH CHANGES IN HABITS, ATTITUDES, AND GAINING SELF-SUFFICIENCY

46. Generally, the best fuel economy is associated with:

    A. Low vehicle weight
    B. Automatic transmission
    C. Large engines

47. The most efficient way to save gas when accelerating is to:

    A. Accelerate as fast as possible
    B. Accelerate as slowly as possible
    C. Accelerate smoothly and moderately

48. The average occupancy per commuter car is:

    A. 1.3 people B. 2.0 people C. 2.6 people

49. By increasing the average occupancy per commuter car by one person, the nationwide gasoline savings would be approximately:

    A. 100,000 barrels per day
    B. 300,000 barrels per day
    C. 600,000 barrels per day

50. Before driving your car, the best way to save gas is to:

    A. Check the tire pressure
    B. Clean your gas filter
    C. Plan your trip to avoid congested areas

MODULE SEVEN

ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

Prepared

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ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

One of the best options to energy conservation is to select a renewable source and harness it to reduce conventional energy use. Through the combination of, e.g., wind and solar energy, electrical energy from conventional sources can be reduced.

TERMINAL PERFORMANCE OBJECTIVE

Identify a select renewable alternative energy source and construct a working device that will utilize that source.

Achievement of the terminal performance objective will be accomplished by successfully completing seven instructional packages. Perhaps you already know something about the seven topics. If this is true, you may wish to take the pretest to determine the extent of your knowledge. The results of the precheck may be used to diagnose and prescribe the instructional packages you need to complete in this instructional module. If you feel you do not have enough knowledge about these topics, you may eliminate the pre-check and begin the first instructional package: the results of your own individual diagnosis and prescription may be recorded below.

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1	Identifying Alternative Energy Sources	____	____
IP-2	Examining Wood as Renewable Alternative Energy Source	____	____
IP-3	Investigating Alcohol as Renewable Alternative Energy Source	____	____
IP-4	Conserving Energy Using Passive Solar Techniques	____	____
IP-5	Examining Solar Energy-Hot Water Systems	____	____
IP-6	Examining Solar Energy-Hot Air Systems	____	____
IP-7	Building and Installing Solar Devices	____	____

PRE-CHECK

ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

Directions: Complete the multiple choice questions that follow. If you miss more than one question per instructional package, you will need to devote time in learning that area.

IP-1. Identifying Alternative Energy Sources

_____1. Alternative energy sources are those that:

A. Are in common usage.
B. Can not be adapted to large scale usage.
C. Are not expensive.
D. Are not in primary usage.

_____2. Renewable energy sources are those:

A. That we can purchase again after our present supply is used up.
B. That are replaced by natural processes.
C. Whose replacement rate equals or surpasses their consumption rate.
D. That have an inexhaustable supply.

_____3. One type of alternative energy source is:

A. Oil
B. Coal
C. Nuclear
D. Solar

_____4. The following is not a renewable energy source:

A. Wood
B. Bio-mass
C. Wind
D. Petroleum

_____5. Which of the following are alternative energy sources?

A. Ocean thermal electric conversion
B. Shale oil
Tar sands
D. Alcohol
E. All of the above C.

PRE-CHECK (Continued)

ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

IP-2. Examining Wood as Renewable Alternative Energy Source

_____1. Wood is sold in a volume of 128 cubic feet which is called a

A. Board foot
C. Lineal r

_____2. Wood will yield the highest BTU rating when

A. Dry
B. Green
C. Cut for a few days
D. Cut into short lengths

_____3. Wood is burned most efficiently in

A. Open fires
B. Fireplaces
C. Stoves with controlled drafts
D. All of the above

_____4. Creosote formed when wood is burned is caused by

A. Long burns between restoking
B. Incomplete combustion
C. Cool surfaces
D. All of the above

_____5. Chimneys serve the two basic functions of carrying hot gases safely away and

A. Preventing downdrafts
B. Reducing air pollution
C. Creating a draft to bring air into the fire
D. None of the above.

IP-3. Investigating Alcohol as Renewable Alternative Energy Source

_____1. The two basic kinds of alcohol used for fuel are ethanol and

A. Isopropyl alcohol
B. Methyl alcohol
C. Pure grain alcohol
D. None of the above

_____2. Ethanol is produced by the fermentation of sugars while methanol is made from

A. Wood
B. Natural Gas
C. Coal
D. All of the above

PRE-CHECK (Continued)

ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

_____3. "Proof" is a term used to describe alcohol

A. Purity
B. Taste
C. Burning ability
D. BTU rating

_____4. In order for engines to run on fuel grade alcohol, you would have to modify

A. Compression ratios
B. Fuel air mix
C. Some rubber and plastic compounds
D. All of the above
E. None of the above

_____5. What product below is not one that is used in producing alcohol as a fuel?

A. Mash
B. Enzymes
C. Water
D. Sugar

IP-4 Conserving Energy Using Passive Solar Techniques

_____1. The first and simplest approach to passive solar heating is

A. Isolated gain
B. Indirect gain
C. Direct gain

_____2. Design pattern considerations for solar passive applications would not include:

A. Building rate
B. Building site and orientation
C. Location of thermal mass
D. Location of thermal mass
E. None of the above

_____3. Which of the following would not be found in a solar passive unit?

A. Trombe wall
B. Clerestory windows and skylights
C. Greenhouse system
D. Differential thermostat

_____4. Which of the following is an indirect gain element of passive solar energy?

A. Clerestory windows
B. Roof pound
C. Thermosiphon effect
D. None of the above

PRE-CHECK (Continued)

ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

_____5. The period between the absorption of solar radiation by a material and its release into a space is

A. Time lag
B. Time warp
C. Transmittance
D. Thermocirculation

IP-5 Examining Solar Energy-Hot Water Systems

_____1. Which of the following terms is not associated with the hardware for a solar hot water system?

A. Differential thermostat
B. Solar constant
C. Glazing
D. Absorber plate

_____2. One of the methods of combatting the freezing of water in a solar hot water system is

A. The drain down system
B. Eutectic salts
C. A vapor barrier
D. Infrared radiation

_____3. For high temperature applications of solar hot water, you would use

A. Roof pond
B. Flat plate collector
C. A concentrating collector
D. A water wall

_____4. A common antifreeze for a solar hot water system is

A. Glauber's salt
B. Polypropylene
C. Methanol
D. Ethylene glycol

IP-6. Examining Solar Energy-Hot Air Systems

_____1. The most common storage medium for a solar hot air system is

A. Glauber's salt
B. water
C. Air
D. Trombe walls

_____2. A major advantage of an air system is

A. It will not freeze
B. It is compatible to most on-line home heating systems
C. A very small storage volume is needed
D. No back-up system is normally needed

PRE-CHECK (Continued)

ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

_____3. Which of the following is a piece of hardware associated with a hot air system?

A. Pump
B. Valve
C. Baffle
D. None of the above

_____4. In an air system, heat transfer is accomplished basically by

A. Convection
B. Conduction
C. Infiltration
D. Radiation

IP-7 Building and Installing Solar Devices

_____1. A major consideration in deciding to build and install a solar device is

A. Idealogical
B. Moral
C. Sociological
D. Economic

_____2. A helpful method of determining the feasibility of installing a solar device is

A. Heat loss
B. Energy audit
C. BTU rating
D. None of the above

_____3. Which of these skills would probably apply to solar installation?

A. Sheet metal
B. Plumbing
C. Masonry
D. None of the above

_____4. Because it is an important component of the energy ethic, you should give consideration to this before deciding to build and install solar devices:

A. Conservation
B. Energy independence
C. Use conventional fuels to stabilize costs
D. All of the above

PRE-CHECK KEY

ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

IP-1. Identifying Alternative Energy Sources

1. D
2. D
3. D
4. D
5. E

IP-2. Examining Wood as Renewable Alternative Energy Source

1. B
2. A
3. C
4.
5. C

IP-3. Investigating Alcohol as Renewable Alternative Energy Source

1. B
2. D
3. A
4. B
5. C

IP-4. Conserving Energy Using Passive Solar Techniques

1. C
2. A
3. D
4. B
5.

IP-5. Examining Solar Energy-Hot Water Systems

1. B
2. A
3. C
4. D

PRE-CHECK KEY (continued)

ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

IP-6. Examining Solar Energy-Hot Air Systems

1.
2. B
3. C
4. A

IP-7. Building and Installing Solar Devices

1. D
2.
3. A
4. A

ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

IP-1 Identifying Alternative Energy Sources

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Distinguish between those sources of energy that are renewable and those that are finite.

B. List alternative sources of energy and write a synopsis of each.

RESOURCES

Before you begin the activity for this learning package, review the resources listed below.

Books:

Producing Your Own Power. Stoner, C.H. (ed). Rodale Press Book Div: Emmaus, PA 18049, 1974.

Handbook of Homemade Power. The Mother Earth News. Bantam Books: New York, NY 10019, 1974.

Energy Primer: Solar, Water, Wind & Biofuels. Merrill, Richard, et al. Menlo Park, CA: Portolo Institute, 1974.

Films:

Challenge of the Future. DOE, Oak Ridge, TN

Energy: The American Experience. DOE, Oak Ridge, TN

Energy: New Sources. DOE, Oak Ridge, TN

Energy for the Future. DOE, Oak Ridge, TN

ACTIVITY

A. Review the instructional resources for IP-1.

B. Prepare a list of alternative energy sources and synopsis of each. Also determine and list each as being renewable or finite.

FEEDBACK

Objective A Check:

1. Have you reviewed the resources listed?

Yes _____ No _____

2. Do you have each source listed as either renewable or finite?

Yes _____ No _____

Objective B Check:

1. Have you reviewed the resources listed?

Yes _____ No _____

2. Check your list and synopsis with the list of alternative energy sources in appendix IP-1. You should have 85% accuracy.

85% Accuracy Yes _____ No _____

Renewable Energy Sources

Biomass
Ocean Currents
Ocean Thermal Electric Conversion
Solar
Tidal
Waves
Wind
Hydro Power
Peat
Wood

Finite Energy Sources

Coal Tar
Coal Liquefaction
Fuel Cells
Geothermal
Nuclear
Oil Shale

ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

IP-2 Examining Wood as An Alternative Energy Source

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Identify the characteristics of wood burning and the quantitative measure of heat produced.

B. List the hazards of wood burning and list the preventive measures for each. Start with the harvesting of wood and work through the complete cycle.

C. Investigate the economics of wood to determine if it is a viable source for the individual and commercial applications.

RESOURCES

Review the learning resources listed below as they relate to wood.

Books:

Heating with Wood. Weeks, S.A., J.P. Lassoie, and L.D. Baker. Cornell University: Ithaca, NY.

Producing Your Own Power. Stoner, C.H. (ed). Rodale Press-Book Division: Emmaus, PA 18049, 1974.

Wood Heat. Agricultural Extension Service. North Carolina State University: Raleigh, NC, 1980.

Fact Sheets:

SYNERGY: WOOD FOR HOME USE. Agricultrual Extension Service, North Carolina State University, Raleigh, NC

SYNERGY: INFORMATION ON WOOD AS A FUEL. Agricultural Extension Service, North Carolina State University, Raleigh, NC.

SYNERGY: SELECTING A WOOD STOVE. Agricultural Extension Service, North Carolina State University, Raleigh, NC.

SYNERGY: FIREWOOD-MEASUREMENT AND HEAT CONTENT. Agricultural Extension Service, North Carolina State University, Raleigh, NC. IP-2, 1-2

SYNERGY: WOOD STOVE INSTALLATION AND SAFETY. Agricultural Extension Service, North Carolina State University, Raleigh, NC. IP-2, 3-4

ACTIVITY

A. Prepare a table of woods common to your area. Show their burn characteristics and the BTU rating of each for seasoned and green wood.

B. Make a list of the hazards associated with wood processing and the burning of wood. Also list the preventive measures for each hazard.

C. Prepare a position paper showing pertinent data for your situation showing whether or not wood would be a viable energy source for you.

FEEDBACK

Objective A Check:

1. Check your figures against those in SYNERGY: FIREWOOD-MEASUREMENT AND HEAT CONTENT located in the appendix.

Compared Yes _____ No _____

Objective B Check:

1. Check your list of hazards and preventive measures with the hazard information provided in the appendix 1P-2.

Compared Yes _____ No _____

Objective C Check:

1. Compare your calculations with those on the economics of wood heat found in the appendix.

Favorable _____ Not Favorable _____

1p-2,1-1

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FIREWOOD — MEASUREMENT AND HEAT CONTENT

Firewood is sold many different ways, usually by the cord, face cord or pickup load. The standard cord is the only legal unit of measurement for selling firewood in North Carolina.

The standard cord is a *volume* measurement. It is 128 cubic feet -- a pile of wood 4 feet high, 8 feet across, with the individual pieces 4 feet long, or its equivalent. This volume includes wood *and* air spaces.

The cubic volume of any pile of wood can be determined by measuring its height, the length of the pile, and the length of the pieces, all in feet. The cubic volume can then be divided by 128 to determine how many standard cords the pile contains. Example: 5 feet high, 10 feet long, 2 feet wide equals approximately 8/10 cord (5 × 10 × 2 divided by 128 = .78).

The volume of actual wood in a cord depends on the diameter of the pieces, whether the wood is split or not, how straight the individual pieces are and how tightly the wood is stacked. Large diameter, split logs generally contain more volume per cord than small diameter, unsplit wood.

The amount of heat in wood is determined by its weight and moisture content, *not by its volume*. A cord of the densest species of wood like oak and hickory weigh more and have a higher heat content than less-dense species like white pine and yellow poplar at the same moisture content. This means equal weights of different species of wood at the same moisture content usually have similar heat contents.

When wood is burned in a stove or fireplace, heat is used to evaporate water from the wood before heat is given off. This is why dry wood produces more useable heat than an equal volume of wet wood of the same species.

The heat contents of some of the common wood species used for firewood in North Carolina are shown in TABLE 1.

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1 P- 2,1-2

TABLE 1

HEAT CONTENTS OF SOME COMMON WOOD SPECIES USED FOR FIREWOOD IN NORTH CAROLINA

WOOD SPECIES[1]	Weight of wood at 20% moisture content POUNDS/CU. FT.[2]	Ave. weight of 80 cu. ft. of solid wood at 20% m. c.[3] POUNDS	Possible recoverable heat per cord of 80 cu. ft. of solid wood[4] MILLIONS OF BTU'S	Available heat per cord burned at 55% heating efficiency MILLIONS OF BTU'S[5]
Hickory	46.4	3712	25.8	14.2
White Oak	44.9	3592	24.9	13.7
Red Oak, Beech	43.4	3472	24.1	13.3
Sugar Maple, Birch	41.9	3352	23.3	12.8
Ash	41.2	3296	22.8	12.5
Slash, Longleaf Pine	40.4	3232	20.4	11.2
Red Maple	36.7	2936	20.4	11.2
Loblolly, Shortleaf Pine	35.2	2816	19.5	10.7
Sweetgum	34.4	2752	19.1	10.5
Tupelo, Elm	34.4	2752	19.1	10.5
Sycamore	34.4	2752	19.1	10.5
Virginia Pine	33.7	2696	18.7	10.3
E. Red Cedar	32.9	2632	18.3	10.1
Yellow Poplar	30.0	2400	16.6	9.1
E. White Pine	25.5	2040	14.1	7.8

[1] Species ranked from highest heat content to lowest.

[2] Computed from specific gravity based on weight when ovendry and volume green.

[3] There are approximately 80 cubic feet of solid wood per 128 cubic-foot standard cord.

[4] Conversion factors: At 20 percent moisture content. There are 8,600 BTU'S per pound of dry wood fiber. It takes 1,400 BTU'S to evaporate one pound of water from wood.

[5] Modern air-tight wood stoves are capable of providing 55 percent of the heat available from burning wood. Some provide more, some less.

1 P-2,1-3

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WOOD STOVE INSTALLATION AND SAFETY

Above all else, stoves should be installed safely. The potential fire hazards of heating with wood are fires started by:

1. Radiation from the stove, stovepipe or chimney.
2. Sparks and glowing coals escaping from the stove.
3. Flames escaping from a faulty chimney.
4. Conduction of heat from chimney into combustible material.
5. Burning or glowing material escaping from top of chimney.

To prevent fire hazards the National Fire Protection Association (NFPA) has formulated installation standards for wood stoves.

Walls and Ceilings

The following are minimum clearances from combustible walls and ceilings for free-standing stoves.

	Radiant Stove	Circulating Stove	Size of Stovepipe
Unprotected	36"	12"	18"
1/4" asbestos millboard	36"	12"	18"
1/4" asbestos millboard spaced out 1"	18"	6"	12"
28-guage sheet metal on 1/4" asbestos millboard	18"	6"	12"
28-guage sheet metal spaced out 1"	12"	4"	9"
28-guage sheet metal on 1/8" asbestos millboard spaced out 1"	12"	4"	9"

Floors

Standards to Protect Floors from Radiant Heat and Burning Material

1. Never place a stove on an unprotected combustible surface.
2. Place stove on sturdy non-combustible floor that extends at least 18 inches beyond the stove on the sides with doors or other potential openings.
3. Suitable materials are 24-guage or thicker sheet metal, 1/4-inch or thicker asbestos millboard covered with 24-guage sheet metal, mortared bricks or stone, concrete, etc. Floor shields can be bought ready made, or they can be custom made.

Chimney Connector (Stovepipe From Stove to Chimney)

Standards for Fire Safety and Draft

1. Steel stovepipe should be at least 24-guage.
2. Secure each stovepipe joint with a minimum of three sheet metal screws.
3. Stovepipe spans longer than 6 feet should be provided with outside mechanical support.
4. Stovepipe should be accessible.
5. Stovepipe should be made physically secure to chimney. (Use high temperature cement.)
6. Stovepipe should penetrate through to inner surface of masonry wall, but not into flue space.

7. Clearance between stovepipe and combustible surface must be at least 18 inches.
8. Stovepipe must not pass through a ceiling.
9. If stovepipe passes through a wall, it must be protected in one of the following ways:
    a. A metal ventilated thimble is used where diameter is at least 12 inches larger than the stovepipe's diameter, giving at least 6 inches of ventilated, metal-lined clearance around the pipe.
    b. A metal or burned fireclay thimble is used and is surrounded by fireproofing materials (such as brickwork) extending at least 8 inches beyond the thimble.
    c. No thimble is used and no combustible material is within 18 inches of the pipe. The hole may be closed in or covered with non-combustible materials such as masonry, asbestos millboard or sheet metal.
10. Diameter of stovepipe should be no smaller than the stove's pipe collar diameter to assure adequate draft.
11. The stovepipe should be no longer than three-fourths the height of chimney from flue collar to top.
12. The horizontal distance of stovepipe should slope up towards chimney 1/4 inch per foot.
13. Stovepipe should be limited to two 90-degree turns.
14. Sections of stovepipe should be placed into pipe below it to prevent creosote or condensate from leaking to outside.

Chimney

Chimney Standards for Wood Stoves

1. Factory built metal chimneys should be designed for wood fuel. ("class A" chimneys).
2. Masonry chimneys should have fireclay flue liners.
3. Stovepipe should not be connected to a flue that serves a fireplace unless the fireplace or its flue are sealed. (Do not connect two or more appliances to the same flue.)
4. Chimneys should terminate at least 3 feet above the roof where they penetrate through it, and at least 2 feet higher than any part of the roof within 10 horizontal feet.
5. Chimneys should be inspected for leaks and excessive creosote build-up.

Additional Precautions

In addition to the previously listed standards, the following precautions should be taken:

1. Use a spark arresting screen ($\frac{1}{2}$-inch mesh) on top of chimney (Keep screen clean.)
2. Use smoke detectors around wood burning stoves as well as in sleeping areas.
3. Keep a water nose or hand-operated sprayer close by for safety.
4. Check with your insurance company to make sure policy covers use of wood stoves.
5. Inspect and clean stove periodically.
6. Locate furniture away from stove area.
7. Store wood a safe distance from stove.
8. Store ashes in non-combustible container or location.
9. Never use gasoline or other highly flammable liquids to start fire.
10. Never allow complacency to create carelessness. Carelessness can cause your home to burn.

Prepared by Housing & House Furnishings Department

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ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

IP-3 Investigating Alcohol as Renewable Alternative Energy Source

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Determine the feasibility of using alcohol as a fuel from the standpoint of economic feasibility, hardware adaptability, and raw material supply.

B. Produce fuel grade alcohol.

C. Produce gasohol.

RESOURCES

Fact Sheets:

The Energy Consumer: Alcohol Fuels. DOE, January 1980.

SYNERGY: QUESTIONS AND ANSWERS ABOUT ALCOHOL AS A FUEL. Agricultural Extension Service. North Carolina State University, Raleigh, NC.

Video Tape:

Alcohol ... Brooks Whitehurst. North Carolina State University, Industrial Arts Education, DOE Workshop, 1981.

Information Sheet: Alcohol Fuels 1P-3,1-5

ACTIVITY

A. Construct an operating packed column distiller (See Appendix IP-3-1-6).

B. Perform the stripping process and refine fuel grade alcohol.

C. Using the plate distiller provided, refine anhydrous alcohol by azetrophic distillation.

D. Produce gasohol.

FEEDBACK

Objective A Check:

1. Present your feasibility study to your instructor for approval.

____
Instructor Approval

Objective B Check:

1. Quote the quantitative amount of fuel grade alcohol you were able to produce.

____

2. Did the engine provided run on your alcohol fuel?

Yes _____ No _____

Objective C Check:

1. Quote the quantitative amount of anhydrous alcohol you produced.

____

2. Was there any evidence of water in your gasohol as shown by the separation of water due to its higher specific gravity and sinking to the bottom?

Yes _____ No _____

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IP- 3,1

IP- 3-1 Activity

Resource Alcohol Fuels Dr. John Tashner, Appalachian State University

BUILD A STILL (FEDERAL PERMIT REQUIRED)

EQUIPMENT NEEDED

1 TESTTUBE

1 BEAKER

1 CORK FOR THE TESTTUBE

1 L - SHAPED GLASS TUBE

1 COLLECTION CONTAINER

MASH SOLUTION

CONVERSION ENZYMES

YEAST

PROCEDURES

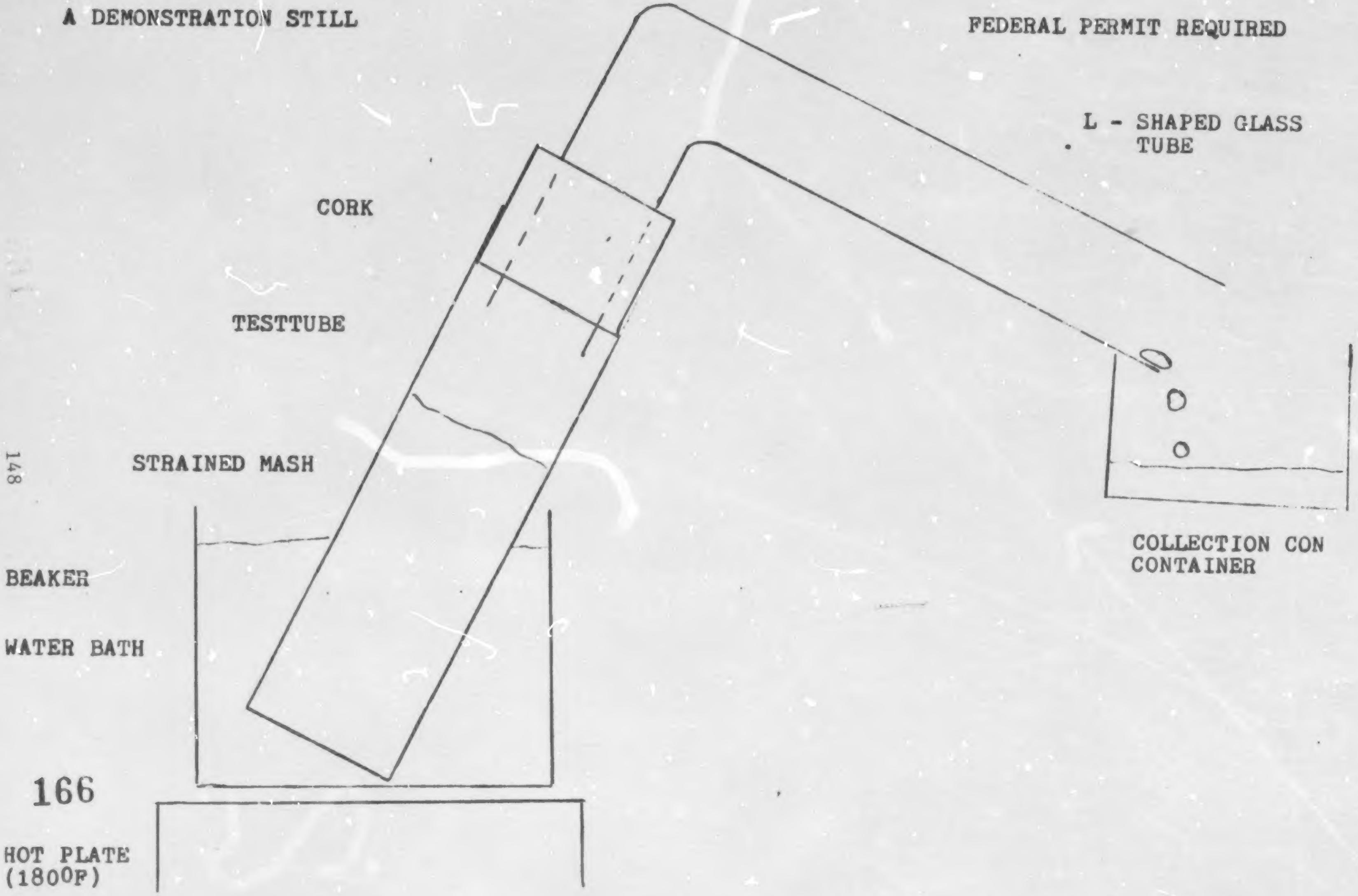
1. PREPARE MASH ACCORDING TO RECIPES ON ATTATCHED PAGE.

2. FERMENT YOUR SOLUTION ACCORDING TO THE INSTRUCTIONS ON THE ATTATCHED PAGES. AFTER 3-5 DAYS STRAIN THE LIQUID AND PLACE IN THE DISTILLATION TESTTUBE.

3. DISTILL THE LIQUID BY PLACING THE DISTILLATION TESTTUBE IN A BEAKER 3/4 FULL OF WATER. HEAT THE WATER TO 180°F. COLLECT THE DROPLETS EMERGING FROM THE GLASS TUBE IN THE COLLECTION CONTAINER. THIS IS ETHANOL, AN ALCOHOL FUEL.

A DEMONSTRATION STILL

FEDERAL PERMIT REQUIRED


L - SHAPED GLASS TUBE
CORK
TESTTUBE
STRAINED MASH
COLLECTION CON CONTAINER
BEAKER
WATER BATH
HOT PLATE (180⁰F)

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IP-352

FERMENTATION

Fermentation is the process that takes place when yeast (a plant-like growth) is grown in a sugar-water solution. When yeast plants are grown in sugar - water they use the sugar for food and give off alcohol and carbon dioxide as by-products. The carbon dioxide is released as a gas, leaving an alcohol-water solution for distillation.

Fermentation is a very simple process. Adding yeast to sugar-water (the result of conversion which is explained below) begins the process which completes in 3 to 5 days. Since carbon dioxide gas is given off while yeast are growing, you can tell that the process has been completed when carbon dioxide stops bubbling off. Because carbon dioxide gas can build up pressure during fermentation, you should not cover your fermentation tightly. A loose covering of plastic wrap or a fermentation lock, available in wine-maker shops, is sufficient. Do not, however, leave the fermentation open to the air. Wild yeast could get into the container, causing unpleasant odors, and fruit flies which get into an uncovered fermentation tank can cause it to turn to vinegar. Vinegar makes a poor fuel.

Yeast plants die in their own waste when the concentration of alcohol in the liquid reaches between 15 and 20 percent, depending on the type of yeast you use. The yeast supplied with your kit is designed to have a high resistance to alcohol and works very well. Yeast may die early, however, if the yeast has been stored too long or if the temperature of the fermentation is allowed to drop below 70 Degrees F. You can determine whether or not the fermentation has reached it's maximum potential by using your small hydrometer.

Before adding yeast to the sugar-water, use the small hydrometer to test a sample. The small hydrometer is calibrated to read the potential alcohol that will result from the fermentation of your sugar-water. Record the reading. When your fermentation stops, take another reading. You will then be able to tell whether the fermentation reached maximum potential. For instance: If your first reading was 18%, that would mean that the final result of a complete fermentation would yield 18% alcohol. If your reading after fermentation stops is 5%, then the fermentation stopped with only a 13% (18%-5% = 13%) density of alcohol having been achieved in your mash. You would then re-start the fermentation by adding more yeast. If, on the other hand, the second reading is 0%, then you have achieved a total conversion of sugar to alcohol.

The step-by-step instructions for making a good mash are explained in the section on mash methods but remember that this is a process that is learned by doing. In a way, it is an art, and you must work with the process to become proficient. We advise that you begin with small fermentations, and work up to 30 or 50 gallon capacities over a period of time as you learn. Once you reach this stage, you can put down large quantity mashes and process the results in 5 gallon batches through your still on the weekend.

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CONVERSION

In order for yeast to ferment, the yeast plant needs a simple sugar to feed on. The naturally occuring sugars such as sugar cane and fruit sugars are ideal for this purpose. In countries where there are large domestic supplies of cane sugar, making fuel alcohol is simple; the sugar from the cane is mixed with water and fermented. Distillation produces fuel alcohol. In North America where there is no large supply of naturally occuring sugars, we must take one additional step. This involves the conversion of starch, a complex form of sugar, into the simple sugars which the yeast plants need for growth.

We have an abundance of starch in the form of a highly developed agriculture. Potatoes, corn, rice, and a whole host of grains and tubers are high in starch content. Conversion is the process of extracting the starch from these plants and converting the starch to simple sugar.

Extracting the starch is very simple. We simply mash (grind, grist or mill) the plant material, mix it with water and apply heat for a short period of time. You do this every time you boil vegetables for a meal - the water, or "pot likker,' you pour down the drain is full of starch.

Nature, too, converts starch to sugar. At the time plants germinate, they must convert the starch to sugar to supply growth energy for the plant. In order to make the conversion, plants produce something known as enzymes. These enzymes are a very powerful bacteria-like material which achieve the conversion very quickly and completely. We are able to produce these enzymes inexpensively in the laboratory and we can use them to convert starch to sugar for the purpose of fermentation. The use of enzymes makes alcohol as a fuel practical in our country.

A very small quantity of enzymes converts a surprisingly large quantity of starch to sugar. The exact amounts are given in the section on mash methods. While learning the process, however, you may wish to skip the conversion of starch to sugar by mixing table sugar with water to start your fermentation. This is not an economical way to make fuel but doing a small batch of about 5 gallons in this way is a very good way to learn the process. (Note: enzymes and yeast may be purchased from your local dealer or from Victory Stills)

MASH METHODS

Method #1

This first method is very general in nature and is used to take advantage of the waste vegetables and fruits that the average family throws away each day. No exact quantities are given. You will learn by experimentation.

1. Collect starchy vegetable leftovers (don't forget to include any "pot likker") and any leftover fruits or fruits juices, or anything else containing sugar or starch. You may also be able to work out an arrangement with the local grocery store to buy fruits and vegetables that are going bad for a reduced price.

2. Mash up these fruits and vegetables, adding enough water to give the mash a soupy consistancy. Add 1/4 teaspoon of Victory Enzyme I for each five gallons of your mash and stir.

3. Heat the mash quickly to the boiling point and boil for 30 minutes.

MAKING GASOHOL

Gasohol is a mixture of 10% anhydrous alcohol and 90% gasoline. Since anhydrous means alcohol without any water content, i.e. 200 proof, and since your still will not produce 200 proof alcohol, we must use other means to remove the small amount of remaining water from your alcohol. A still will not do the job because of the small amount of chemical bonding that occurs between alcohol and water. A still separates two liquids due to a difference in their boiling temperatures. Generally, alcohol boils at a much lower temperature than water, but when we reach a very high proof, the formation of the chemical bonds makes the liquids boil at the same temperature, thus ruling out the still as the means of futher separation.

It is necessary to remove the water from the alcohol. Gasoline can cause alcohol to lose the remaining water under certain conditions of temperature and, since water has a higher specific gravity than either alcohol or gasoline, it will sink to the bottom. The gas tank of your car will always have some water in it due to condensation, but we do not want to increase the problem by using an improper gasohol mixture. Water in your tank can cause your car to cut off if it gets into the fuel lines, which, while it will not harm your car, can be very inconvient.

In order to remove the water from the alcohol, we can use one of several methods. Certain chemicals can be added in the distillation process to prevent alcohol and water from forming chemical bonds. Another method is to add a chemical (sodium hydroxide) to the alcohol after it is produced to absorb the water so that it will not cause a problem. Since sodium hydroxide is inexpensive and readily available, you may wish to use this method. Another method which works (though we admit it is somewhat primitive) is to simply mix your alcohol in a container with gasoline. Since the gasoline will cause the water to separate and fall to the bottom of the container, it can be siphoned from the bottom of the container. You would then pour the alcohol and the gasoline mixture into your tank.

While this method would be impractical on a commercial scale, it works quite well in the quantities we are dealing with.

One question about this method remains. How do you know if you have removed enough water? It is really very simple to calculate.

When you measure the proof of your alcohol, you learn what percentage is water. Once you remove close to this amount, it is safe to pour in your tank. As an example: If you have a gallon of 190 proof alcohol, then we know that it is 95% alcohol (divide proof by 2) and the remaining 5% is water. A gallon contains 128 ounces, so once we have removed close to 6.4 ounces of water (128 x 5%) the mixture can then be poured into your tank.

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4. Add another 1/4 teaspoon per five gallons of mash, and allow it to stand for 10-15 minutes. 1P-3, 5

5. This completes you conversion of starch to sugar. You may test for complete conversion at this point with ordinary household iodine. Take a small quantity of your mash and add a drop of iodine. If the color of the sample turns pink, then the conversion is complete. If the color of the sample turns blue or purple, then you have not converted all the starch to sugar. In this instance, you should add more enzyme and boil the mash again.

6. Pour your mash into a fermentation tank (a small trash can is ideal). Test with your small hydrometer, as explained, and record the reading. If the reading is above 15% to 20%, then add enough water to bring the reading down to these levels.

7. Add 1/4 teaspoon of Victory Enzyme II for each five gallons of mash. This enzyme contains yeast nutriants (much like fertilizer for plants) and some citric acid to adjust the acidity for best yeast action.

8. You now add your yeast. The mash temperature should be between 70 and 90 degrees F. when the yeast is added and should be kept in this range during the entire fermentation period. Since yeast are plants, they will multiply as they grow. Mix 1/2 teaspoon of yeast with a small quantity of warm water for each five gallons and put the dissolved yeast into your mash.

9. After 3 to 5 days, your fermentation will be complete. Strain the liquid (wash) and place it into your Victory Still distillation kettle. Follow the distillation directions to extract your fuel alcohol.

Method #2

This is an exact measurement method based on a bushel of corn. You may increase or decrease the quantities as long as you keep the same porportions.

1. Start with one bushel of well milled corn (corn meal). A bushel of corn when milled equals 54 pounds of corn meal.

2. Add 30 gallons of water.

3. Follow the directions given under method #1, starting with number 2.

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ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

IP-4 Conserving Energy Using Passive Solar Techniques

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Determine how much solar energy is available for our utilization.

B. Discover ways this available energy can be used without applying active energy to it.

RESOURCES

Books:

The Passive Solar Energy Book. Mazria, Edward. Rodale Press-Book Div.: Emmaus, PA 18049, 1977.

Passive Solar Design Handbook, Volumes 1 and 2 DOE, 1980.

Films:

Solar Design. HUD.

The Solar Builders. HUD.

ACTIVITY

A. Read Units 1 through 4 from The Passive Solar Energy Book.

B. Perform any two of the following classroom activities from Solar Energy Experiments: C, D, and E.

C. Complete experiments 10 and 11 from Solar Energy Experiments.

FEEDBACK

Objective A Check:

1. Present your calculations to your instructor for approval.

____
Instructor's Approval

Objective B Check:

1. Have you completed classroom activity C?

Yes _____ No ______

2. Have you completed classroom activity D?

Yes _____ No ______

3. Have you completed classroom activity E?

Yes _____ No ______

4. Have you completed experiment 10?

Yes _____ No ______

5. Have you completed experiment 11?

Yes _____ No ______

ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

IP-5 Examining Solar Energy-Hot Water Systems

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Discover ways hot water can absorb, store, and transfer solar energy.

RESOURCES

Books:

The Passive Solar Energy Book. Mazria, 1979.

Active Solar Heating and Cooling. Solar Energy Research Institute, DOE.

Factsheet:

Energy Storage Technology. Solar Factsheet, DCE.

ACTIVITY

A. Complete experiment 14 in Solar Energy Experiments.

FEEDBACK

Objective A Check:

1. Present the results of experiment 14 to your instructor for evaluation.

____
Instructor's Approval

ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

IP-6 Examining Solar Energy-Hot Air Systems

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Discover ways that air can absorb, store, and transfer energy.

RESOURCES

Books:

Solar Energy Experiments. Norton, 1978.

The Passive Solar Energy Book. Mazria, 1980.

Producing Your Own Power. Stoner, 1980.

Harness the Sun. Keyes, John. Conestoga Graphics Publication: Denver, CO, 1974.

Active Solar Heating and Cooling. Seri, DOE.

Factsheet:

Energy Storage Technology. Solar Factsheet, DOE.

ACTIVITY

A. Complete experiment 16 in Solar Energy Experiments.

FEEDBACK

Objective A Check:

1. Present the results of experiment 16 to your instructor for approval.

____
Instructor's Approval

2. Submit your completed plans for the solar device to your instructor for approval.

____
Instructor's Approval

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ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

IP-7 Building and Installing Solar Devices

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Demonstrate a knowledge of solar design and construction.

B. Demonstrate basic skills associated with solar energy construction.

C. Make calculations related to the solar energy application.

RESOURCES

Books:

The Passive Solar Energy Book. Mazria.

Build It Book of Solar Heating Projects. Foster.

Solar Hot Water and Your Home. National Solar Heating and Cooling Center.

The Solar Energy Notebook. Wilson.

Passive Solar Design Handbook, Volumes 1 and 2. DOE.

Harnessing The Sun. Keys.

Solar Energy Experiments. Norton. 1978.

Magazines:

Mechanics Illustrated. June 1978.

ACTIVITY

A. Design, construct, and evaluate a working solar hot air or hot water collector.

FEEBACK

Objective A Check:

1. Present your design of a solar device to your instructor for a critique and modify where needed.

   Modifications Made: Yes _____ No _____

Objective B Check:

1. Have you completed your solar device according to your specifications?

   Yes _____ No _____

2. Have your instructor examine your solar device for craftsmanship.

   Excellent _____ Good _____ Fair _____ Poor _____

Objective C Check:

1. Does your solar device work?

   Yes _____ No _____

2. Submit your calculations and evaluation of your device to your instructor for final approval.

   Approved: Yes _____ No _____

POST-CHECK

ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

Directions: If the statement is true, circle the letter "T." If the statement is false, circle the letter "F."

T F 1. The energy in wind is renewable.

T F 2. Nuclear energy is an alternative source of energy.

T F 3. Alcohol is a relatively new source of energy that historically has never been used before.

T F 4. OTEC stands for Ocean Thermal Electric Conversion.

T F 5. Biomass is plant material in any form from algae to wood.

T F 6. This is the first time in the history of man that he has had to seek alternative energy sources.

T F 7. Oil shale is a renewable energy source.

T F 8. A renewable energy source is one whose replacement rate equals or surpasses its consumption rate.

T F 9. Coal liquefiaction is a natural process occurring in nature so no energy has to be expended to accomplish the process.

T F 10. Energy from the geothermal process is theoretical and probably will not be utilized in the near future because of its many complications.

T F 11. Wood is sold in a volume of 128 cubic feet which is called a cord.

T F 12. About 80% of the accidents in the woods involved with wood harvesting result from unsafe working habits and only 20% from unsafe conditions.

T F 13. Felling a tree is the process of cutting it into lengths.

T F 14. Booking a tree is the process of relieving tension on a downed tree supported at two points.

T F 15. Stoves should be placed at least 36" away from combustible materials.

POST-CHECK (Continued)

ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

T F 16. Wood yields its highest BTU rating when green.

T F 17. A dampen is not needed with wood stoves.

T F 18. Creosote formation increase with cooler surfaces.

T F 19. Flue fires are more likely to start when you have a very hot fire in your heater.

T F 20. Wood fireplaces are more efficient than wood stoves.

T F 21. The purpose of a chimney is to carry hot gases away from the fire and to create a draft, thus bringing air into the fire.

T F 22. The total length of a stovepipe should be less than 10 feet.

T F 23. Where masonry chimneys are not available or practical, a UL approved ALL FLUE metal chimney can be used.

T F 24. The stovepipe may be redused between the stove and the chimney flue.

T F 25. The stovepipe may enter the flue at a point that is lower than the outlet of the stovebox.

T F 26. Fermentation is the process that takes place when yeast is grown in a sugar-water solution.

T F 27. Conversion is the process of exracting the starch from plants and converting the starch to simple sugar.

T F 28. A still separates two liquids due to a difference in their boiling point.

T F 29. Gasohol is a mixture of 20% alcohol and 80% gasoline.

T F 30. Isopropel alcohol is a fuel grade alcohol.

T F 31. Methanol is made from wood, coal, and natural gas.

T F 32. "Proof" is a term used to describe alcohol taste.

T F 33. Compression ratios and fuel air mixes would be needed to run an engine on alcohol.

T F 34. Enzymes are used to speed up conversion of starch to sugar.

POST-CHECK (Continued)

ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

T F 35. Two Hundred (200) proof is 100% pure alcohol.

T F 36. Passive solar energy utilizes outside energy to collect heat.

T F 37. A trombe wall is an example of indirect gain.

T F 38. The angolan distance between true south and the point on the horizon directly below the sun is the azimuth.

T F 39. Time lag is the time it takes heat to travel through an object.

T F 40. The solar constant is the amount of solar reaching the earth's surface.

T F 41. The angle of incidence is the angle that the sun's rays make with a line perpendicular to a surface.

T F 42. Insolation is the amount of solar radiation striking a surface exposed to the sky.

T F 43. Retrofitting is installing a solar system in a new structure.

T F 44. A clerestory window is one placed low in a wall.

T F 45. A berm is a man-made mound or small hill of earth.

T F 46. A dimu down system uses antifreeze to combat freezing.

T F 47. High temperature how water application in solar energy utilize flat plate collectors.

T F 48. Heat transfer is the amount of heat that can be driven from one medium to another.

T F 49. The four main elements of a solar hot water system are the collector, storage tank, auxiliary heat supply, and the control system.

T F 50. A solar concentrating system normally will incorporate a tracking device.

T F 51. Rock is a common storage medium for solar air systems.

POST-CHECK (Continued)

ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

T F 52. In an air system heat transfer is largely due to radiation.

T F 53. A baffle is a device used in an air system to block the reverse flow or escape of air.

T F 54. Most often solar air systems are compatible with existing forced air systems.

T F 55. Air is a convenient and easy medium to work with in solar applicators.

T F 56. Skills in heating and air conditioning will transfer to solar construction.

T F 57. You should be able to estimate costs of construction and payback periods to determine economic feasibility of solar energy.

T F 58. The moral and social justifications for utilizing solar energy are unimportant.

T F 59. The technology needed to utilize solar energy is several years away.

T F 60. The orientation of a collector is unimportant to the amount of heat it can collect.

POST-CHECK KEY

ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

IP-1 Identifying Alternative Energy Sources

1. T
2. F
3. F
4. T
5. T
6. F
7. F
8. T
9. F
10. F

IP-2 Examining Wood as Renewable Alternative Energy Source

11. T
12. T
13. F
14. T
15. T
16. F
17. F
18. T
19. T
20. F
21. T
22. T
23. T
24. F
25. F

IP-3 Investigating Alcohol as Renewable Alternative Energy Source

26. T
27. T
28. T
29. T
30. T
31. T
32. F
33. T
34. T
35. T

POST-CHECK KEY (Continued)

ENERGY CONSERVATION THROUGH THE SELECTION AND APPLICATION OF RENEWABLE ALTERNATIVE SOURCES

IP-4 Conserving Energy Using Passive Solar Techniques

36. F
37. T
38. T
39. T
40. F
41. T
42. T
43. T
44. F
45. T

IP-5 Examining Solar Energy-Hot Water Systems

46. F
47. F
48. T
49. T
50. T

IP-6 Examining Solar Energy-Hot Air Systems

51. T
52. F
53. T
54. T
55. T

IP-7 Building and Installing Solar Devices

56. T
57. T
58. F
59. F
60. F

MODULE EIGHT

ENERGY USED IN SMALL BUILDINGS AND HOMES

Prepared

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June 1981 - R.E. Wenig, Director

ENERGY USED IN SMALL BUILDINGS AND HOMES

Energy conservation is based on controlling energy uses in the home and in small buildings. Households and small buildings use about 21% of the total energy in the nation. It is important to become aware of the major uses of energy in the home so that efforts can be made to conserve and more efficiently use it. The willingness to conserve energy will help to make more productive use of the world's and America's resources.

Students should become more aware of the energy uses in the home. It is the purpose of this module to help students recognize the major uses of energy in the home and develop habits and attitudes toward better conservation.

TERMINAL PERFORMANCE OBJECTIVE:

Given the resources of energy uses in the home, survey major appliances (such as space heating and cooling, electric appliances) and determine the relative consumption of each as measured in the appropriate units (compare energy used in the home with energy used on the national level by referring to the resource).

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1.	Inventory Energy Uses in the Home	____	____
IP-2.	Compare Energy Uses in the Home with "Monthly Energy Requirements of Household Appliances"	____	____
IP-3.	Draw a Floor Plan of the Home and Locate the Position of Energy Uses	____	____

PRE-CHECK

ENERGY USED IN SMALL BUILDINGS AND HOMES

DIRECTIONS: Answer the following by placing a "T" for true or an "F" for false on the blank.

IP-1. Inventory Energy Uses in Home

_____1. A meter used to measure the amount of electricity used is called a kilowatt hour meter.

_____2. The dials on a power meter all turn in the same direction.

_____3. The information on appliances that refers to energy use factors such as volts, watts, ampers, etc. is found only on the shipping box or crate.

IP-2. Compare Energy Uses in the Home With "Monthly Energy Requirements of Household Appliances"

1. Inventory the appliances in the home (inventory in IP-1) and compare with the "Monthly Energy Requirements of Household Appliances" - Form C.

IP-3. Draw a Floor Plan of the Home and Locate the Position of Energy Uses

_____1. A floor plan includes the walls of the home.

_____2. The symbol for a light fixture is a small circle with a line through the circle.

_____3. There is more than one source of energy uses that services the home.

PRE-CHECK KEY

ENERGY USED IN SMALL BUILDINGS AND HOMES

IP-1. Inventory Energy Uses in Homes

1. T
2. F
3. F

IP-2. Compare Energy Uses in the Home with "Monthly Energy Requirements of Household Appliances"

An inventory of appliances used in the home will have to be compared with the "Monthly Energy Requirements of Electric Household Appliances."

IP-3. Draw a Floor Plan of the Home and Locate the Position of Energy Uses

1. F
2. T

ENERGY USED IN SMALL BUILDINGS AND HOMES

IP-1 Inventory Energy Uses in Homes

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Inventory the energy users in the home.

B. Calculate the relative consumption of each appliance as well as the total energy consumed in a twenty-four (24) hour period of time.

RESOURCES

Books:

Providing for Energy Efficiency in Homes and Small Buildings. USDOE. Publication 06065, Part 1; Education Division, Washington, DC 20585, pp. 43-48.

Pamphlets:

Tips for Energy Savers. Federal Energy Administration, Publication FEA/D 77/212, August 1977, pp. 32-33.

Award Winning Energy Education Activities for Elementary and High School Teachers. Energy Research and Development Administration Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830, pp. 19-20, 24-29.

Handouts:

Monthly Energy Requirements of Electric Appliances IP- 1

Local Utilities Monthly/Yearly Need and Rate Information

Home Energy Conservation Primer. Vogel et al., West Virginia University, Morgantown, WVA 26506, August 1980, pp. 521.

ACTIVITY

A. Using 1P-1,1-2. write down the readings of appliances that are used in the home as recorded, opposite the ones listed on the handout(1P-1-3

B. Record the total amount of energy used in the home for a twenty-four hour period (this was a previous assignment). Record the percentage of each appliance relative to the total amount of energy used in twenty-four hours, using 1P-1,3

C. List the appliances and equipment that use the most energy in twenty-four hours, using 1P-1,3

FEEDBACK

Objective A Check:

A. Complete 1P-1,1 and check

Instructor's Approval

1P-1.1

January 29, 1981

MONTHLY ENERGY REQUIREMENTS OF ELECTRIC HOUSEHOLD APPLIANCES

APPLIANCES	TYPICAL WATTAGE	APPROX. OPERATING COST PER HOUR	APPROX. KWH USED PER MONTH	APPROX. MONTHLY COST
Air Conditioner (Window) 12 Hrs. Use - 6,000 BTU 115 Volt	860	4.3¢	310	$ 15.50
12 Hrs. Use - 12,000 BTU 230 Volt	1,950	9.8¢	702	$ 35.10
Electric Blanket (8 Hrs. use per day)	190	8.0¢/day	46	$ 2.30
Broiler	1,500	7.5¢		
Clock	2		1.5	7.5¢
Clothes Dryer (55 min. cycle) 7 loads/week ($5.87/Month)	5,500	27.5¢/load		
"Crock-Pot"	70/140	.6¢		
Coffee Maker	1,000	5.0¢		
Compactor	1,380		3	15.0¢
Deep Fryer	1,620	8.1¢		
Dehumidifier 24 hrs. use 22 pts./day	600		14.4/day	72.0¢/day
Dishwasher Including hot water 32 loads/month	800	16.0¢/load	102	$ 5.10
Dripping Faucet - slow			40	$ 2.00
Dripping Faucet - medium			80	$ 4.00
Dripping Faucet - fast			120	$ 6.00
Fan (Attic)	370	1.8¢		
Fan (Circulating) 10 hrs. use/day	88	4.4¢/day		
Burner & Fan (furnace-oil) 6 months use-1375 hours	836		192	$ 9.60
Fan (Roll-about)	171	0.9¢		
Fan (Window)	200	1.0¢		
Food Mixer	127	0.6¢		
Food Waste Disposer	445		2.5	12.5¢
Frying Pan	1,600	7.9¢		
Hair Dryer (soft bonnet)	400	2.1¢		
Hair Dryer (hard bonnet)	900	4.5¢		
Hair Dryer (hand held)	600	2.9¢		
Heater (radiant)	1,650	8.2¢		
Hot Plate	1,650	8.2¢		
Humidifier - 6 hrs./day	115	5.0¢	21	$ 1.05
Iron (hand)	1,000	5.0¢		
Lamps, Fluorescent (6 hrs./day) 40 watt 48" (inc. ballast)	50		9	45.0¢
(6 hrs./day) 80 watt 96" (inc. ballast)	100		18	90.0¢
Lamps, Incandescent 60 watt size (6 hrs./day use)	60		11	55.0¢
100 watt size (6 hrs/day use)	100		18	90.0¢
Microwave Oven 15 min. per day use	1,460	7.3¢	11	55.0¢

1 P-1.2

Radio	75	3.7¢/10 hrs.		
Radio-Phonograph-Stereo	125	6.3¢/10 hrs.		
Range	12,000		110	$ 5.50
Refrigerator Side-by-side, no frost				
22 cu. ft.	495		180	$ 9.00
22 cu. ft./customer dispenser	495		186	$ 9.30
Refrigerator 2 door (top mount) no frost				
21 cu. ft.	475		167	$ 8.35
18 cu. ft.	475		165	$ 8.25
16 cu. ft.	475		138	$ 6.90
14 cu. ft.	475		129	$ 6.45
Refrigerator 2 door (top mount) cycle defrost				
14 cu. ft.	475		110	$ 5.50
12 cu. ft.	475		97	$ 4.85
Refrigerator Single-door, manual defrost - 10 cu. ft.	300		58	$ 2.90
Food Freezer No frost upright				
16 cu. ft.	475		210	$ 10.50
Food Freezer Upright, manual defrost				
15 cu. ft.	475		155	$ 7.75
12 cu. ft.	440		137	$ 6.85
Food Freezer Chest, manual defrost				
20 cu. ft.	400		140	$ 7.00
15 cu. ft.	400		119	$ 5.95
Sun Lamp	150	0.8¢		
	300	1.5¢		
Television (B&W) (8 hrs. per day)	150	0.8¢	36	$ 1.80
Television (Color) (8 hrs. per day)	300	1.5¢	72	$ 3.60
Television Instant On when "off"				
B&W (Solid State)	13		9	45.0¢
Color (Solid State)	16		11	55.0¢
Toaster	1,320	6.5¢		
Toaster Oven	1,500	7.7¢	14	70.0¢
Vacuum Cleaner	920	4.6¢	6.0	30.0¢
Waffle Iron	1,200	6.0¢	1.2	6.0¢
Washing Machine Only	300	1.5¢/Load	10	50.0¢
Washing Machine Hot wash warm rinse includes cost of hot water based on 30 gallons of hot water per wash	300	43.6¢/Load	263	30 Loads/Mo. $ 13.15
(58 minute cycle)				
Water Heater (4 in family)	4,500		409	$ 20.45
Water Pump	460		75	$ 3.75

NOTE: Cost figures are based on 5.0¢ KWH. These cost figures do not reflect the basic customer charge for residential customers. "CP&L, RALEIGH,NC

1P- 1,3

INVENTORY OF ENERGY USE

APPLIANCE	ENERGY SOURCE	WATTS	ESTIMATED KWH/24 HRS	MONTHLY REQUIREMENTS	ESTIMATED USE/MO	

ENERGY USED IN SMALL BUILDINGS AND HOMES

IP-2 Compare Energy Uses in the Home With "Monthly Energy Requirements of Household Appliances"

OBJECTIVE

Upon completion of this instructional package, you will be able to:

A. Compare the results of energy uses in the home previously recorded with the Estimated Yearly Use of Energy and Operating Costs.

RESOURCES

Handouts:

Home Energy Conservation Primer. Vogel, Michael P., et al. West Virginia University, Morgantown, WVA. August 1980, pp. 521, Table 5.D

Iowa Developed Energy Activity Sampler, Industrial Arts, Grades 7 - 12. The University of Iowa, Iowa City. Doris Simmons, pp. 320-321.

Local Utilities Need and Rate Information.

ACTIVITY

A. Define: Ampere (i)
Volts (E)
Watts (w)
Kilowatt Hour (KWH)

B. Demonstrate the way to read a kilowatt hour meter used to measure electricity used in the home. After the demonstration, review the sample handout and record the reading of Meter 1 and 2 - see IP-2,1

C. Complete activities 1 - 3, then read a kilowatt hour meter on the home and record the amount of electricity consumed in a twenty-four hour period of time. Calculate the cost of energy consumed based on the current rate. Use the handout "How Much Gas or Electricity Do We Use?". Use IP-2,2

D. Take an inventory of the major appliance used in the house, such as space heating/cooling, lighting, cooking appliances, hot water heater, pumps, etc. and list the energy source of each. Use IP-1,3

E. Read the inspection plate or label on each appliance, light bulb, and equipment to determine the amperes, volts, watts, or the BTU capacity. Remember that even if a furnance is fueled by gas, it has an electric motor to distribute the air (record all data).

F. Calculate the energy consumed in one hour on four of the major appliances used frequently in a twenty-four hour period of time. It would be preferable to calculate this during the time the kilowatt hour meter is being recorded. IP-2,3

FEEDBACK

Objective Check:

A. Define:

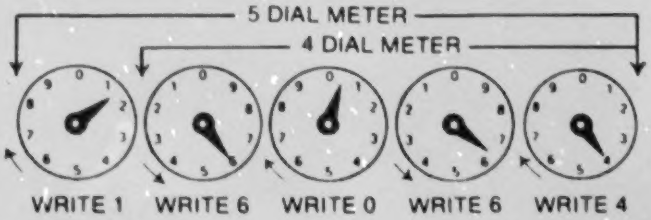
Ampere (i) - a unit of electric current
Volt (E) - a unit of electric pressure
Watt (W) - a unit of electric power
Kilowatt Hour (KWH) - a measure of electricity

1 P-2y1

ENERGY CONSERVATION CORPS

HOW TO READ YOUR ELECTRIC METER

The dials are like watch faces lined in a row (every other dial moves counterclockwise). The reading for a five dial meter would be 16,064. The reading for a four dial meter would be 6,064.

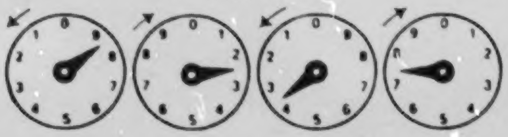


Notice that when the pointer is between two numbers, you should record the lower of the two numbers.

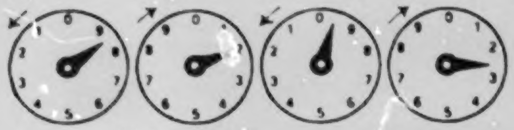
When the pointer seems to be directly on a number, look at the dial to the right; if the pointer on the right side dial has passed "O", then write down the number the pointer seems to be on; if the pointer on the right side dial has not passed "O", then write down the previous lower number on the dial you are recording.

RECORD THE READINGS FOR THE FOLLOWING METERS

METER NO. 1

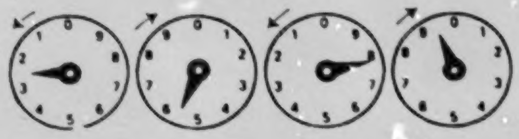


A _ ____ ____ ____ ____

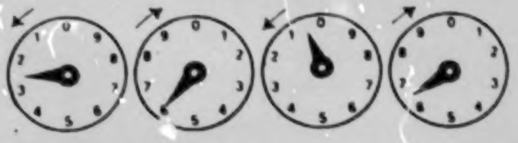


B _______ ____ _____ __

METER NO.2



A _ __________ _____ __



B _ ____ ________ ____

Subtract the number of line A from the number on line B to find the number of KWH of electricity used.

Line B _ __________

Line A _ __________

KWH used ______________

Line B _ __________

Line A __________

KWH used _ ____________

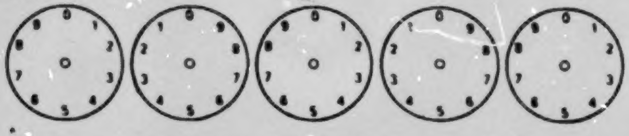
10-2,2

ENERGY CONSERVATION CORPS

METER READING RECORD

ARE YOU SAVING ENERGY? A good way to find out is to keep a record of the electricity you use before and after beginning your conservation effort. The chart below will help you record your progress. 1. Draw the positions of the hands of the meter on the dials each day at the same time. 2. Write the number in the space below each dial and on the line at the right. 3. Subtract the kilowatt hours (KWH) used on day one from the kilowatt hours used on day two. Repeat each day for seven days.

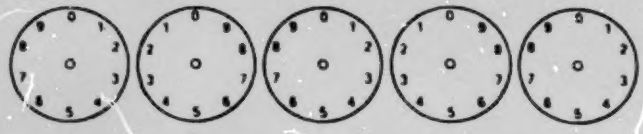
DAY 1



_______ _______ _______ _______ _______

Meter Reading Day 1 ____________

DAY 2



_______ _______ _______ _______ _______

Reading Day 2 ____________

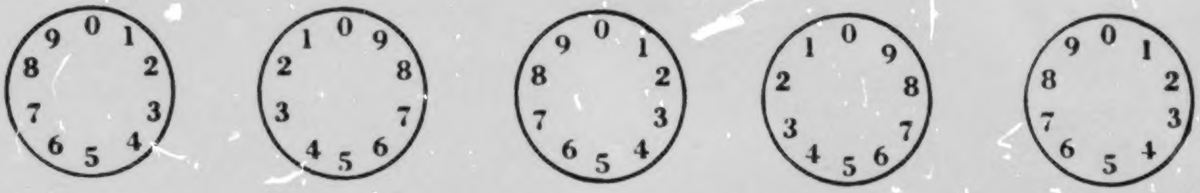
Reading Day 1 ____________

KWH used ____________

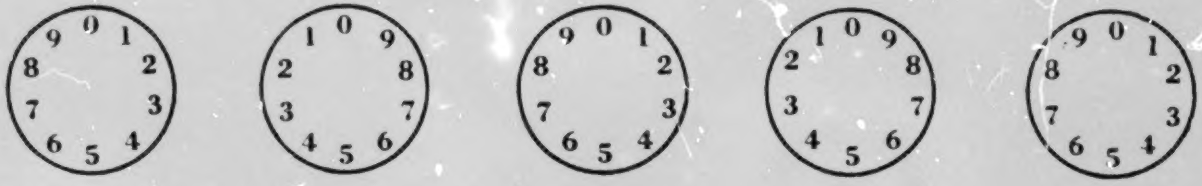
1P-2,3

HOW MUCH GAS OR ELECTRICITY DO WE USE?

Name ______________________________

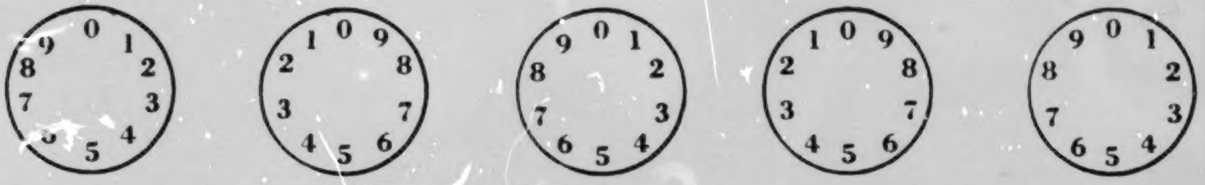


Date __________ Time __________ READING ________________

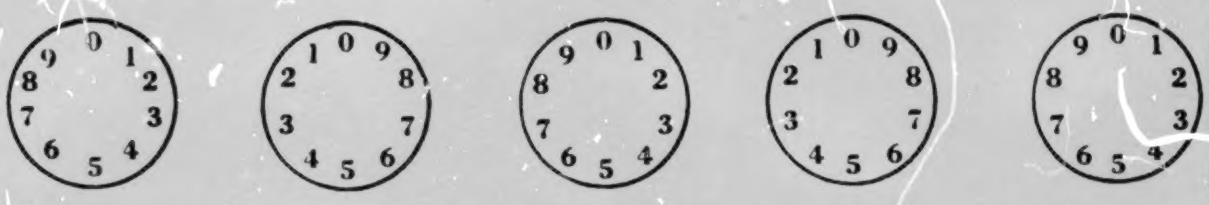


Date __________ Time __________ READING ________________

TRY TO SAVE ENERGY!



Date __________ Time __________ READING ________________



Date __________ Time __________ READING ________________

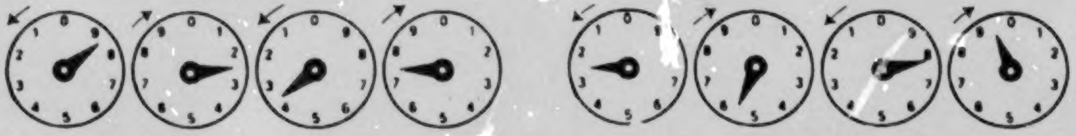
1P-2,4

FEEDBACK (Continued)

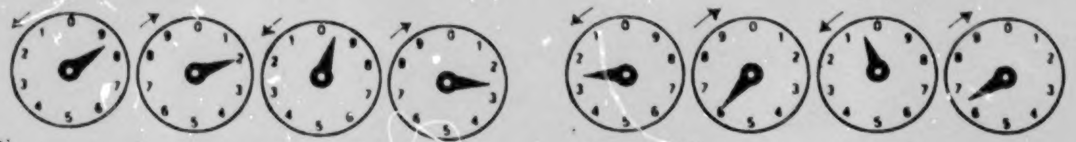
B. Reading of meter 1 and 2 - 1P-1,1

RECORD THE READINGS FOR THE FOLLOWING METERS

METER NO. 1 METER NO.2



A _ 8 _ 2 _ 3 _ [illegible] A _ 2 _ 5 _ 7 _ 9



B _ 8 _ 2 _ 9 _ 2 B _ 2 _ 6 _ 0 _ 6

Subtract the number of line A from the number on line B to find the number of KWH of electricity used.

Line B	8292	Line B	2606
Line A	8237	Line A	2579
KWH used	55	KWH used	27

D. Reading of kilowatt hour meter in a twenty-four hour period of time.

E. Inventory energy uses in the home, 1P-1,

200

ENERGY USED IN SMALL BUILDINGS AND HOMES

IP-3 Draw a Floor Plan of the Home and Locate the Position of Energy Uses

OBJECTIVE

Upon completion of this instructional package, you will be able to:

A. Draw a sketch of a floor plan of the home and locate the position of the incoming source of energy and the relative position of each appliance and lighting.

RESOURCES

Architectural Drawing References with Current Symbols.

ACTIVITY

A. Use graph paper or drawing paper and lay out the floor plan of the home used as a reference for all energy uses. (Sketching or drawing will be acceptable. Include window/door openings and total square feet.)

B. Make a legend using symbols for energy uses in the home and a symbol for each appliance. Use standard symbols commonly used on floor plans. Design a symbol for appliances that don't have a standard symbol.

C. Locate each source of energy on the floor plan, each appliance and lighting that uses energy.

D. Using the comparison of energy uses that was recorded previously, circle the appliances that use the most energy in the home.

E. Use this floor plan and data for calculating energy use in Module #12 and/or various references on energy audit.

FEEDBACK

Objective Check:

A. The completed drawing of the home will be used for the progress check. Use the following check list:

1. Scale of the Drawing ________________
2. Total Number of Square Feet ____________
3. Symbols for Appliances (Legend on Drawing)
4. Circle appliances that use the most energy in the home.

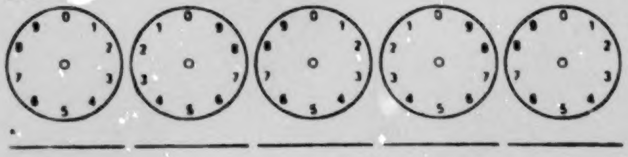
POST-CHECK

ENERGY USED IN SMALL BUILDINGS AND HOMES

The following post-check will evaluate the complete module #8 on "Uses of Energy in the Home and Small Buildings." When completed, you will inventory major uses of energy in the home and be able to compare uses of energy of homes in a community or nation.

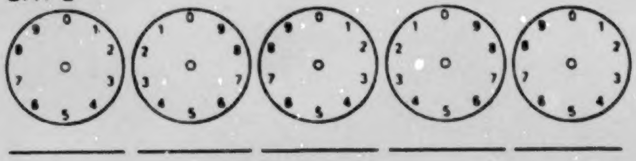
1. Record the reading for Meter Day 1 and Meter Day 2.

DAY 1



Meter Reading Day 1 ______________

DAY 2



Reading Day 2 ______________
Reading Day 1 ______________
KWH used ______________

How much will it cost for the kilowatts recorded for meters 1 and 2 per .5¢/KWH?

2. Match the following terms in the left column with the symbols in the right column, and put the symbols on the blank.

________Volts	KWH
________Watts	W
________Kilowatt Hour	I
________Electric Outlet	E
________Electric Light	

3. Name three major sources of energy uses in the home.

   1.

   2.

   3.

POST-CHECK (Continued)

ENERGY USED IN SMALL BUILDINGS AND HOMES

4. Name three major uses of energy in the home.

   1.

   2.

   3.

5. Name three major items of information found on an appliance inspection plate that will help to determine energy uses.

   1.

   2.

   3.

6. Place a number 1 - 10 beside the appliances that consume the most energy. 1 uses the most energy, 10 uses the least.

______Window Fan
______Air Conditioner
______Electric Frying Pan
______Waffle Iron
______Water Heater
______Television (Color)
______Fluorescent Light
______Radio
______Television (Black & White)
______Clock

MODULE NINE

WAYS AND MEANS OF REDUCING HOME AND SMALL BUILDING ENERGY USE

Prepared

by

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Technology Education Programs
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USDOE Sponsored Faculty Development Workshop on Energy
Conservation for IAE at North Carolina State University
June 1981 - R.E. Wenig, Director

WAYS AND MEANS OF REDUCING HOME AND SMALL BUILDING ENERGY USE

Reducing energy use saves money, conserves natural resources, and enables individuals and nations to become more self sufficient from external forces. This module specifically assists individuals to reduce energy in homes and small buildings.

TERMINAL PERFORMANCE OBJECTIVES

At the completion of this module, the student will be able to:

1. Identify, list, and describe major factors that affect the energy consumption in the home and small buildings;
2. Identify, list, and describe strategies and techniques for conserving energy and modifying factors that affect energy use in small buildings and residential structures.

It should be kept in mind that the purpose of this module is to provide the student with ideas, strategies, techniques, etc., for reducing energy use in buildings. It is not the purpose of the module to provide a detailed analysis or description of how to apply these ideas, strategies, and techniques nor provide estimates of cost and/or fuel savings associated with strategy. Many of the energy saving strategies mentioned within this module are dealt with in detail in other modules.

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1.	Energy Consumption in Small Buildings and the Home	____	____
IP-2.	Factors That Affect Energy in Buildings	____	____
IP-3.	Strategies and Techniques for Reducing Residential and Commercial Energy Consumption	____	____

PRE-CHECK

WAYS AND MEANS OF REDUCING HOME AND SMALL BUILDING ENERGY USE

DIRECTIONS: In the space provided below, select the response that best completes the statement.

IP-1 Energy Consumption in Small Buildings and the Home

TRUE - FALSE

_____1. The residential and commercial sectors consume approximately 36% of the United States' energy.

_____2. Space heating is the second largest consumer of energy in the residential section.

_____3. Water heating consumes more energy than air conditioning in the commercial sector.

_____4. The commerical sector consumes approximately 21% of the U.S. energy budget.

_____5. Space heating is about 58% of the residential energy consumption.

IP-2 Factors that Affect Energy Use in Buildings

SELECT THE STATEMENT THAT DOES NOT FIT.

_____1. Factors that affect energy use - effect of house design

A. Room layout
B. Shape of home
C. Vegetation
D. Size of house

_____2. Factors that affect energy use - insulation

A. R. Value
B. Vapor barrier
C. Superinsulated
D. Infiltration

_____3. Factors that affect energy use - orientation of slopes on the site

A. South facing for maximum solar
B. West facing for maximum afternoon solar exposure
C. East facing for maximum morning solar
D. North for minimum wind and solar exposure

PRE-CHECK

WAYS AND MEANS OF REDUCING HOME AND SMALL BUILDING ENERGY USE

_____4. Factors that affect energy use - vegetation

A. Location
B. Color
C. Distance
D. Size

_____5. Factors that affect energy use -

A. wind
B. Azimuth
C. Altitude
D. Landform

IP-3 Strategies and Techniques for Reducing Residential and Commercial Energy Consumption

TRUE - FALSE

_____1. The Federal government has passed legislation providing energy conservation incentives. The EPCA of 1975, the ECPA of 1976, and the NEA of 1978 are three such legislative acts.

_____2. Home space heating can be reduced by as much as 50% by insulation.

_____3. Taking a bath will generally save more energy than taking a shower.

_____4. One foot fluorescent lamp has a higher per watt than does two 4 foot lamps.

_____5. 120 F is usually an adequate water temperature for a hot water heater.

PRE-CHECK KEY

WAYS AND MEANS OF REDUCING HOME AND SMALL BUILDING ENERGY USE

IP-1. Energy Consumption in Small Buildings and the Home

1. T
2. F
3. F
4. F
5. T

IP-2. Factors that Affect Energy Use in Buildings

1. C
2. D
3. D
4. B
5. A

IP-3. Strategies and Techniques for Reducing Residential and Commerical Energy Consumption

1. T
2. T
3. F
4. T
5. T

WAYS AND MEANS OF REDUCING HOME AND SMALL BUILDING ENERGY USE

IP-1. Energy Consumption in Small Buildings and the Home

OBJECTIVE

This instructional package will help you to understand the amount of energy consumed in the residential and small buildings. It will also help you identify energy consumption in these structures. Upon completion of this instruction package, you will be able to:

A. List and describe major areas of energy consumption in the residential and small building.

RESOURCES

The following resource has been provided for you to use in attaining the objective listed above:

Information Sheet:

Energy Consumption in the Residential and Commercial Sectors IP-1, [illegible]

ACTIVITY

A. Review instructional package resource listed above: Energy Consumption in the Residential and Commercial Sector.

B. List the areas of energy consumption in the residential and commercial sectors in the space provided in Figure 1.

C. Fill in the blanks in Figure 1 with the names of the contributing energy consuming factor adjacent to the correct percentage.

"ENERGY CONSUMPTION IN THE RESIDENTIAL AND COMMERCIAL SECTORS"

Of the total energy consumed in the United States, approximately 36% is used in the residential and commercial sectors. The following diagrams show the areas of energy in these sectors:

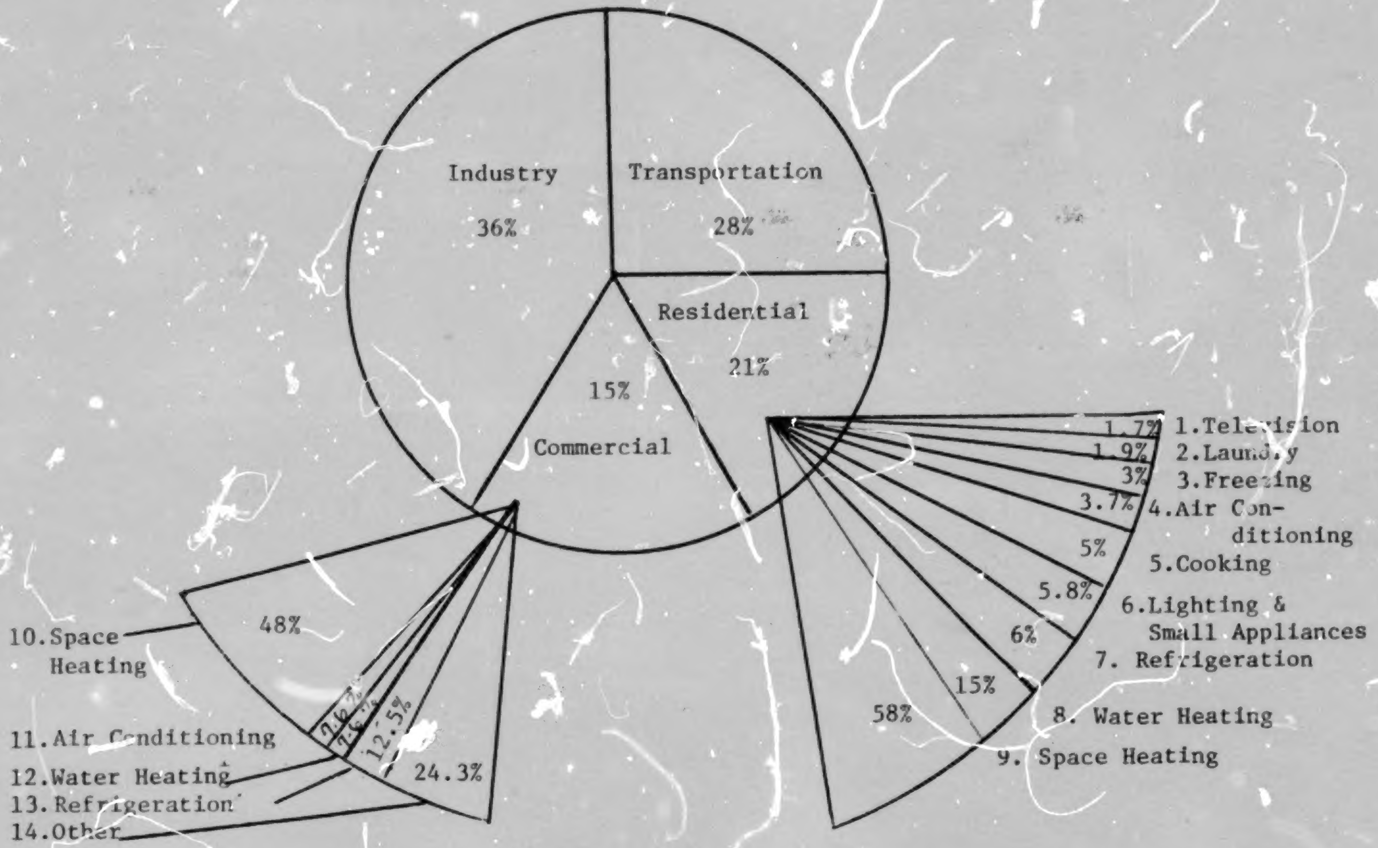

FIGURE 1 Energy Consumed in the Residential and Commercial Sectors in the U.S.

Residential and Commercial sectors consist of housing units, non-manufacturing business establishments (e.g. wholesale and retail businesses), health and educational institutions, and government office buildings. The overall trend in residential and commercial energy use from 1960 to 1977 was growth. Consuming 38% of the nation's energy budget in 1978, the primary applications are for space heating and cooling, lighting, water heating, and operation of small appliances.

Between 1960 and 1972, energy use in buildings grew at an average annual rate of 5 percent. Commercial use grew at over 6 percent per year and residential was under 5 percent. In 1973 energy use trends varied erractically from the pattern of steady increase, with no overall growth through 1975. In 1976 growth resumed at its former rate of 5 percent and continued at the same rate in 1977.

Changes in residential and commercial energy consumption roughly paralleled the rise and fall of economic activity in the 1970's and rising energy prices in the residential sector coincided with the leveling off of consumption. Trends in energy expenditures per household underscore the point. As expenditures for energy rose, household energy consumption declined. In 1976, as price increases continued but at a more moderate rate, consumption per household again turned upward. The same trends are apparent in commercial fuel expenditures.

During the last two decades, the mix of fuels supplying the energy shifted markedly. Electricity's share in the residential sector increased from 26% in 1960 to 46% in 1976, gas declined from 37% to 32%, oil from 26% to 18%, and other fuels - such as coal and propane - declined from 11% to 4%. Similar shifts in fuel choice occurred in the commercial sector. Several factors were important in the shifts: energetic marketing of electricity by utilities, public perception of gas and electricity as cleaner and more convenient than oil, population shifts away from New England where oil is heavily used, shortages of natural gas in the 1970's and onward, and fuel price changes.

Today, office buildings use far more energy, on the average, than do older buildings with an equivalent amount of space. The difference can be traced frequently to building design--hermetically sealed windows create the need for mechanical heating and cooling on days when simple ventilation would provide comfortable indoor temperatures; glass walls add to building heating and cooling requirements because they allow high levels of heat loss and heat gain; and office spaces without any windows require artificial lighting when natural light, if available, would be ample. Furthermore, today's businesses rely on a proliferation of office machines, computers, elevators and escalators.

Convenience and comfort appliances led the growth in household energy consumption in the decade of the 1960's which included air conditioners, clothes dryers, and television. According to the Ford Foundation's Energy Policy Project (study of energy use and lifestyles) almost all American homes now contain five basic energy-consuming items: central heat, hot water heater, stove, refrigerator, and electric lights. Virtually all have one radio and one television as well. Seven out of ten have washing machines. Central air conditioning systems for example, grew from five percent of American households having these systems in 1969 to 15 percent in 1973. Possession of dishwashers increased from six percent to existing within 25 percent of all households during the same period. Clothes dryers, which existed in less than one-fifth of American households in 1960, were found in almost half by 1973.

In some cases, household energy growth has been further stimulated by design changes that diminish the efficiency of energy use. Most refrigerators currently marketed are large, frost-free models requiring about two-thirds more energy per unit than smaller, more economical models with manual defrost. Color televisions typically consume almost half again as much electric power as black and white sets. Sometimes greater energy demand in one area affects demand in other energy sectors as well. For example, dishwashers and automatic washing machines not only use electricity, but require even additional energy for hot water heating.

Residential energy consumption levels are frequently influenced by decisions in which an individual home owner has a little to say. Refrigerators, dishwashers, air conditioners, and hot water heaters are often chosen by the builder, or by the previous homeowner. Home heating systems are replaced less often than most appliances making it even less likely that a current fuel consumer participated in the choice of system for his home. One-fifth of all American households (mostly apartment dwellers) have no control over their thermostat settings. Such residents can exert direct control over their dwelling temperatures only by opening windows or turning on portable electric heaters or blankets. This can add still more to their energy consumption.

Furthermore, the trend toward built-in, energy-consuming features in new homes has grown in the last few years. Builders are incorporating electric heating systems and central air conditioning in an increasing number of homes and apartments, and concrete slab construction without insulation from the cold ground is becoming more common. Overall home design has become less and less oriented toward energy efficiency.

FEEDBACK

Objective A Check:

Residential

1. Television
2. Laundry
3. Freezing
4. Air Conditioning
5. Cooking
6. Lighting and Small Appliances
7. Refrigeration
8. Water Heating
9. Space Heating

Commercial

10. Space Heating
11. Air Conditioning
12. Refrigeration
13. Water Heating
14. Other

WAYS AND MEANS OF REDUCING HOME AND SMALL BUILDING ENERGY USE

IP-2. Factors That Affect Energy Use in Buildings

OBJECTIVE

This instructional package will help you to understand the major factors that affect energy consumption in homes and small buildings. When finished with this instructional package, you will be able to:

A. List and describe major factors that affect energy consumption in the home.

RESOURCES

Book:

Your Energy Efficient House. Odom, Anthony. Charlotte, NC: Garden Way, 1975.

USDOE Booklet:

Providing for Energy Efficiency in Homes and Small Buildings. American Association for Vocational Instructional Materials, In Three Parts, 1980.

Information Sheet from USDOE Booklet:

Climate and Landform - Factors That Affect Energy Use in Buildings. IP-2A, 1-4.

How Design and Construction Methods Affect Energy Use in Residences. IP-2B, 1-17.

ACTIVITY

A. Review instructional package resources listed under RESOURCES.

B. List and explain climate and landform factors that affect energy use in buildings.

INSTRUCTIONS: In the Information Sheet, "Climate and Landform - Factors That Affect Energy Use in Buildings," seven (7) factors which contribute to building energy use were discussed. In outline form, list these factors and give characteristics of each.

___1. ____________

A. ____________

B. ____________

___2. ____________

A. ____________

B. ____________

___3. ____________

A. ____________

B. ____________

___4. ____________

A. ____________

B. ____________

___5. ____________

A. ____________

B. ____________

___6. ____________

A. ____________

B. ____________

___7. ____________

A. ____________

B. ____________

ACTIVITY (Continued)

C. List and explain design and construction factors that affect energy use in buildings.

INSTRUCTIONS: In the Information Sheet, "How Design and Construction Methods Affect Energy Use in Residences," fourteen (14) factors were discussed. In outline form, list the fourteen (14) factors and characteristics of each factor.

___1. ______________
   A. __________
   B. __________

___2. ______________
   A. __________
   B. __________

___3. ______________
   A. __________
   B. __________

___4. ______________
   A. __________
   B. __________

___5. ______________
   A. __________
   B. __________

___6. ______________
   A. __________
   B. __________

___7. ______________
   A. __________
   B. __________

___8. ______________
   A. __________
   B. __________

___9. ______________
   A. __________
   B. __________

___10. ______________
   A. __________
   B. __________

___11. ______________
   A. __________
   B. __________

___12. ______________
   A. __________
   B. __________

___13. ______________
   A. __________
   B. __________

___14. ______________
   A. __________
   B. __________

FEEDBACK

Objective B Check:

Check responses for Activity B. See attached sheet.

Objective C Check:

Check responses for Activity C. See attached sheet.

FACTORS THAT AFFECT ENERGY USE IN BUILDINGS

I. CLIMATE & LANDFORM FACTORS.

1. TEMPERATURE PATTERNS ON THE SITE.
   - DAILY, MONTHLY, AND SEASONAL PATTERN
2. PRECIPITATION PATTERNS ON THE SITE
   - FROST "POCKETS"
   - SNOW DRIFT AND COLLECTION -
   - FOG MOVEMENT, COLLECTION OR PROPENSITY PATTERNS
3. WIND PATTERNS ON THE SITE
   - DAILY, MONTHLY AND SEASONEL PATTERNS
   - LOCAL WIND OBSTRUCTION
4. SOLAR RADIATION PATTERNS ON THE SITE
   - DAILY AND SEASONAL PATH OF THE SUN ACROSS THE SITE
   - SOLAR OBSTRUCTION
5. ORIENTATION OF SLOPES ON THE SITE
   - SOUTH - FACING SLOPES FOR MAXIMUM SOLAR
   - WEST - FACING SLOPES FOR MAXIMUM AFTERNOON SOLAR EXPOSURE
   - EAST - FACING SLOPES FOR MAXIMUM MORNING SOLAR EXPOSURE
   - NORTH - FACING SLOPES FOR MINIMUM SOLAR EXPOSURE - NONE IN THE WINTER
6. TOPOGRAPHY OF SITE
   - STEEPNESS OF THE SLOPE - CAN IT BE BUILT UPON ECONOMICALLY

     PRESENCE OF SLOPES BENEFICAL OR DETRIMENTAL TO ENERGY CONSERVATION AND SOLAR ENERGY UTILIZATION
7. EXISTING VEGETATION
   - SIZE, VARIETY AND LOCATION OF VEGETATION WHICH WOULD INPAIR ENERGY CONSERVATION THROUGH THE CONTROL OF WIND AND THE SUN.

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II. DESIGN AND CONSTRUCTION METHODS THAT AFFECT ENERGY USE IN THE HOME

1. EFFECT OF SITE LOCATION
    - ORIENTATION ON SITE
    - VEGETATION
    - HILL TOPS/SOUTH SLOPE/VS FLAT LAND
2. EFFECT OF DESIGN
    - SIZE AND SHAPE OF HOME
    - ROOM LAYOUT
    - PLACEMENT OF GLASS AND DOORS
    - SLOPE OF ROOF
    - BERMED HOME
3. EFFECT OF MATERIALS USED
    - R VALUE OF MATERIALS
    - BRICK VS WOOD FRAME
    - TYPE OF WINDOWS (OPERABLE VS FIXED)
4. EFFECT OF INSULATION
    - R VALUE OF INSULATION
    - TYPE, APPLICATION AND AMOUNT
    - CONVENTIONAL STANDARD VS SUPERINSULATED
5. EFFECT OF VAPOR BARRIERS
    - CONTROL HEAT LOSS THROUGH MOISTURE CONTROL
6. EFFECT OF WEATHERSTRIPPING AND CAULKING
    - CONTROL INFILTRATION AND AIR CHANGES
7. EFFECT OF WINDOWS AND DOORS
    - WINDOW AND DOOR TYPES
    - PLACEMENT

6

8. EFFECT OF HEATING METHOD
   - SOME MORE EFFICIENT
   - SOME USE NON-RENEWABLE FUEL
   - SOME PROVIDE MORE CONTROL
9. EFFECT OF VENTILATION
   - NATURAL VS FORCED
   - INSULATION AND/OR ISOLATED FROM COLD

- OTHER DESIGN AND CONSTRUCTION FACTORS THAT AFFECT HOME ENERGY USE

10. EFFECT OF AIR CONDITIONING METHOD
11. EFFECT OF LIGHTING METHOD
12. EFFECT OF PLUMBING LAYOUT
13. ENERGY EFFICIENT APPLIANCES

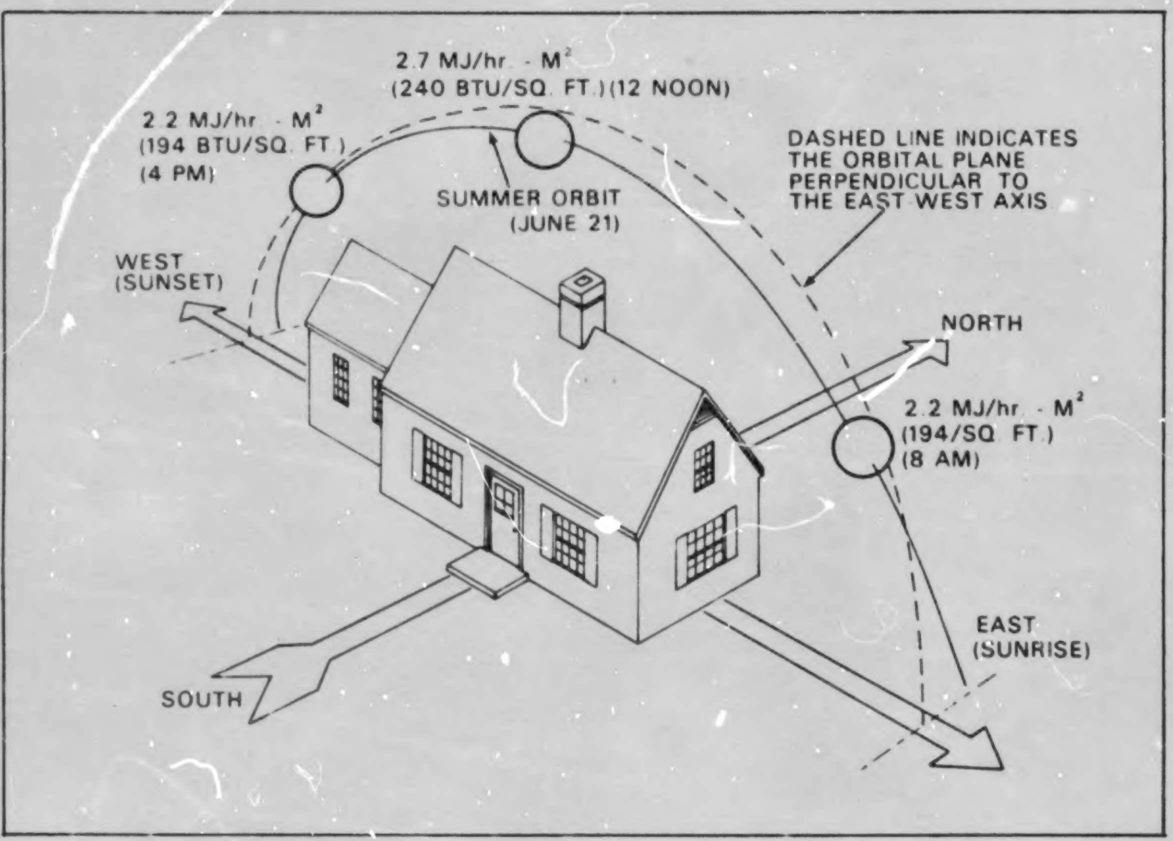
2.7 MJ/hr. - M²
(240 BTU/SQ. FT.)(12 NOON)
2.2 MJ/hr. - M²
(194 BTU/SQ. FT.)
(4 PM)
SUMMER ORBIT
(JUNE 21)
DASHED LINE INDICATES
THE ORBITAL PLANE
PERPENDICULAR TO
THE EAST WEST AXIS
WEST
(SUNSET)
NORTH
2.2 MJ/hr. - M²
(194/SQ. FT.)
(8 AM)
EAST
(SUNRISE)
SOUTH

FIGURE 76. The path of the sun influences the use of energy in buildings.

How Design and Construction Methods Affect Energy Use

Several factors influence the amount of energy used in buildings.

Planning an energy-efficient home or building begins with the selection of the site, followed by the proper orientation of the building on the site. Design of the structure, arrangement of rooms, selection of materials and mechanical equipment are of equal importance in an energy-efficient building. Your understanding of design and construction methods will help you save energy in your building.

From this section you will be able to describe how design and construction methods affect energy use. They are discussed under the following headings:

1. Effect of Site Location.
2. Effect of Design.
3. Effect of Materials Used.
4. Effect of Insulation.
5. Effect of Vapor Barriers.
6. Effect of Weatherstripping and Caulking.
7. Effect of Windows and Doors.
8. Effect of Heating Methods.
9. Effect of Air Conditioning.
10. Effect of Ventilation Method.
11. New Methods of Heating and Cooling.
12. Effect of Lighting.
13. Effect of Plumbing.
14. Energy-Efficient Appliances.

1. EFFECT OF SITE LOCATION

Site location and the orientation of buildings on the site affect the amount of energy used in heating and cooling. The sun and wind are two major factors that influence energy use.

Keep in mind that in the northern hemisphere the sun is high in the sky during the summer and lower on the horizon during the winter.

Hill tops, ridges and higher elevations have more exposure to the wind and are colder in the winter and cooler in the summer. In cold climates, select southern exposures protected by land of higher elevations. Flat sites are open to full sweeps of wind. Air temperatures near large bodies of water are tempered by the wind.

Some trees make good wind screens. Deciduous trees are excellent summer shelters, while evergreens provide shelter the year round.

Room orientation is also important. Rooms of major use oriented to the southern, warmer side of a building capitalize on solar energy.

Energy consumption can be reduced by choosing the site carefully. Site location should vary, depending on the climatic zone. Site locations should be considered for each of the zones as follows:

a. Cold Zone

A house built on the northern or western slope with little or no protection from the prevailing winds will use more energy than one situated on the southern or eastern slope (Figure 77).

Vegetative protection can also be a factor in energy use.

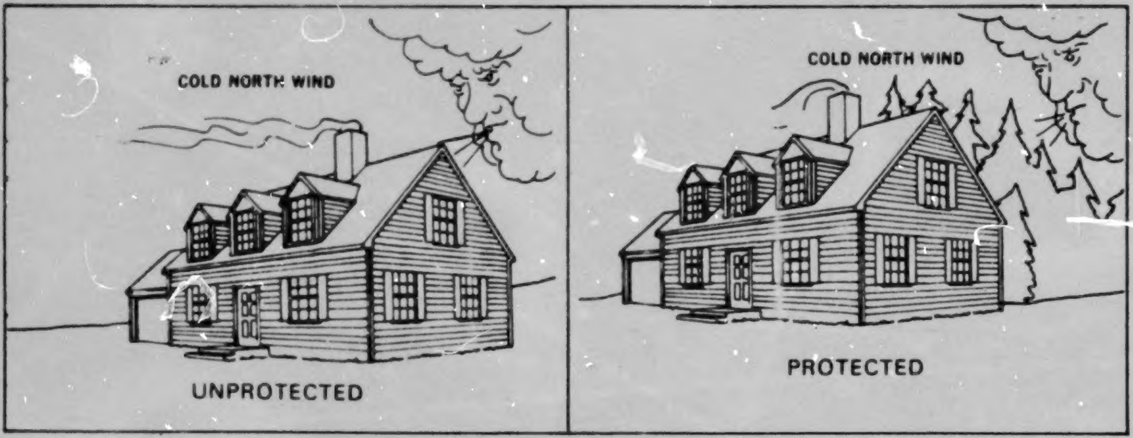

FIGURE 77. Buildings exposed to cold prevailing winds will use more energy for heating than those protected.

b. Temperate Zone

A balance is needed in the temperate zone between protection from wind in winter and access to air in summer. Also, vegetative protection that is used in winter may be used as shade in summer (Figure 78).

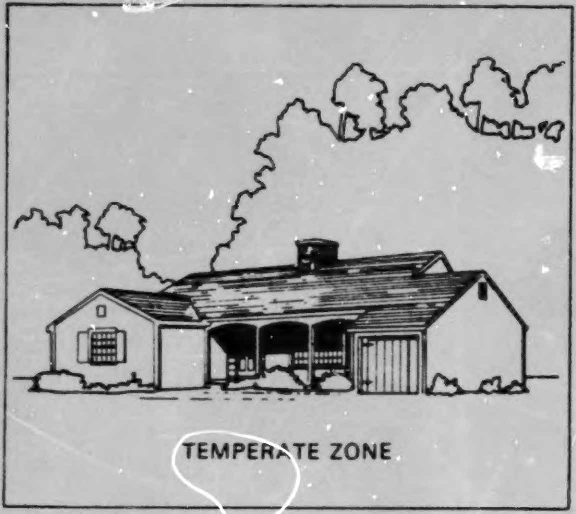

FIGURE 78. A building in the temperate zone should be moderately protected.

c. Hot-Humid Zone

Summer comfort is more important than winter heat in the hot-humid zone. If air circulation is inadequate during summer, excessive energy will be needed for cooling. Houses should be situated on southern and northern slopes with vegetative protection and shade provided (Figure 79).

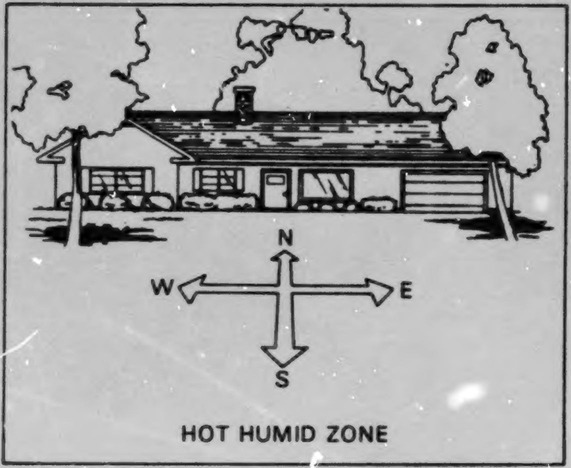

FIGURE 79. Buildings in the hot-humid zone should be oriented toward the north or south with ample shade for summer.

d. Hot-Arid Zone

Houses should be oriented toward the east with afternoon shading (Figure 80). Wind is not important here because it is generally not too cold in winter and it is hot and dry in summer. It is best if you can shield the building from summer prevailing winds.

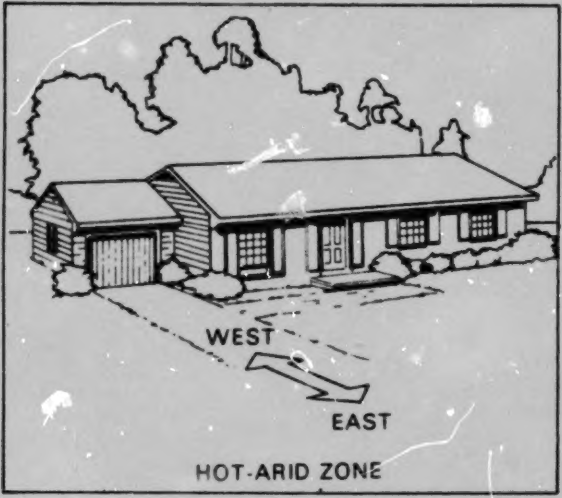

FIGURE 80. Buildings in the arid west should face the east and utilize afternoon shading whenever possible.

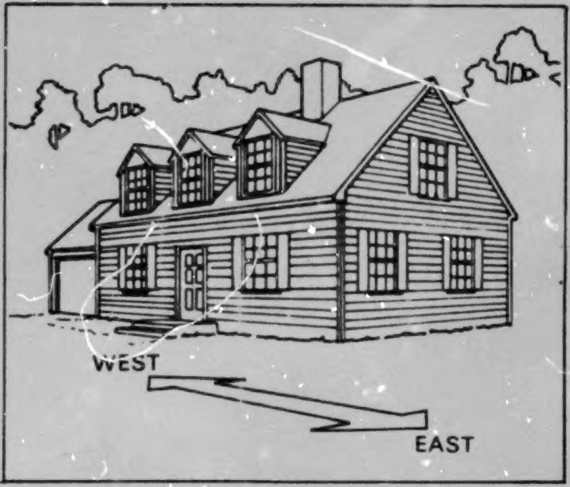

FIGURE 81. Rectangular houses oriented toward east and west generally use less energy year round.

2. EFFECT OF DESIGN

The shape of a building also has an effect on the amount of energy used. Generally, a rectangular house oriented east and west will use the least amount of energy (Figure 81).

Design should allow for exposure of windows to sun in winter and shade in summer (Figure 82). Shades may be used effectively.

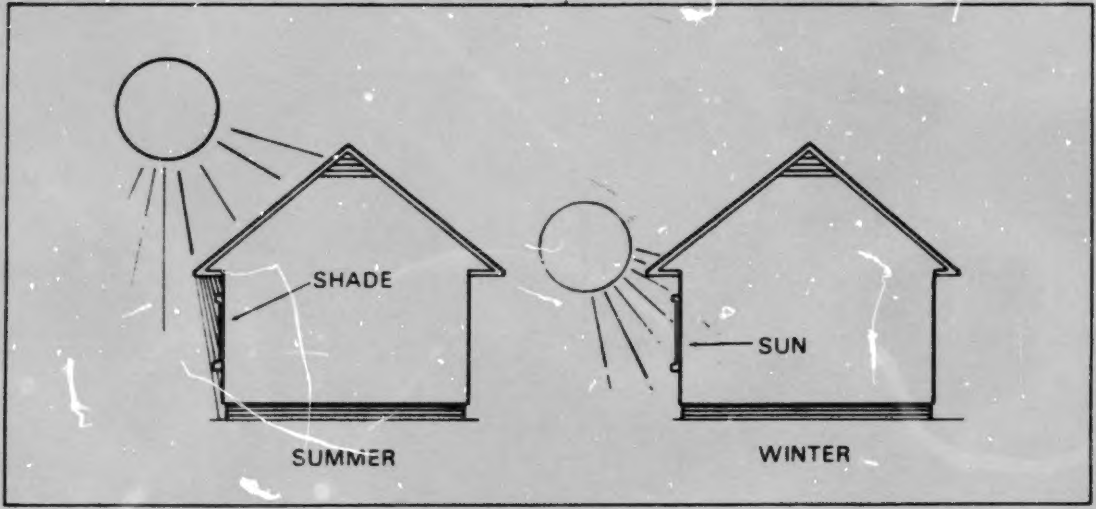

FIGURE 82. Windows should be exposed to sun in winter and should be shaded during summer.

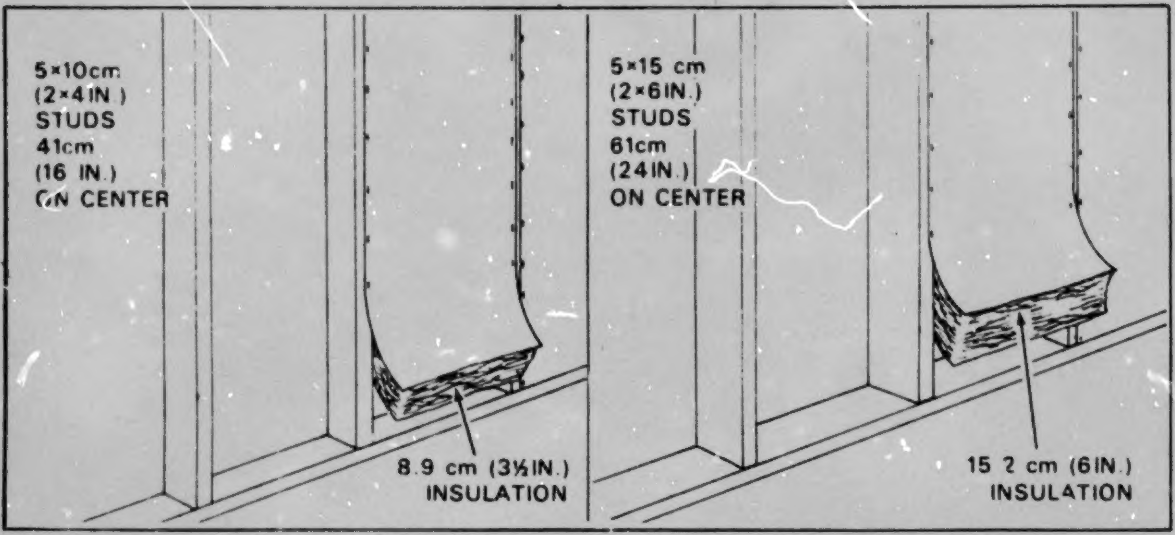
5×10cm
(2×4IN.)
STUDS
41cm
(16 IN.)
ON CENTER
8.9 cm (3½IN.)
INSULATION
5×15 cm
(2×6IN.)
STUDS
61cm
(24IN.)
ON CENTER
15.2 cm (6IN.)
INSULATION

FIGURE 84. Structures may be designed to accommodate more insulation.

Designers are changing their philosophy about buildings. The "anything goes" attitude which was characteristic of the past decade has suddenly evolved into a functional and efficient approach to building design. For example, rambling structures are being replaced with cubicle buildings which have a minimum of exterior surface area. Such measures cut down on one of the greatest sources of heat loss.

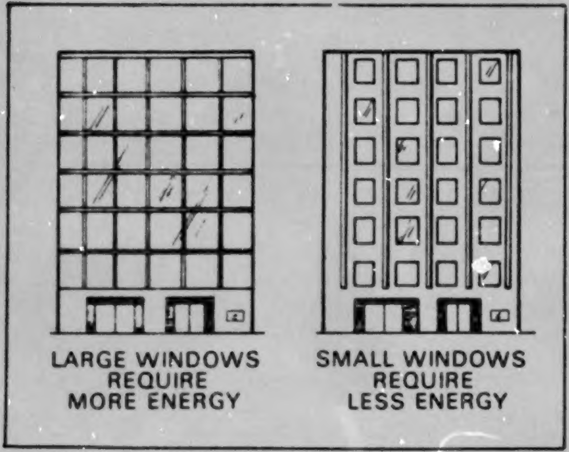
LARGE WINDOWS
REQUIRE
MORE ENERGY
SMALL WINDOWS
REQUIRE
LESS ENERGY

FIGURE 83. Large windows require more energy than small windows.

The use of glass has become an important factor in design. Before energy conservation was important, designs with large expanses of uninsulated and unprotected glass were common. Now the amount of glass used in many building designs is being reduced (Figure 83). Nearly everywhere in the continental United States, south-facing windows admit more heat than they lose. To effectively reduce heat loss through windows, at least two layers of glass are needed in cold climates. A third layer of glass, or movable insulation (curtains or shutters) covering the glass at night, can reduce heat loss further. An overhang or other shading will cut unwanted summer heat.

Designs are being adopted which utilize better insulation. A new design innovation is the Arkansas System which recommends 5.1 x 15.2 cm (2 x 6 in) stud framing to accommodate more insulation (Figure 84).

Additional conservation measures include the utilization of insulated doors and multi-pane windows. General, overhead lighting fixtures are being replaced by task lighting.

Many factors are taken into consideration, including the orientation of the house, slope of the roof, hours of sunshine, prevailing winds and site latitude.

Mechanical equipment should not impose large loads on the utility system during peak periods. The selection of oversized equipment should be avoided. In commercial buildings, the most significant features include the use of insulation, proper fenestration, control of ventilation, levels of illumination, orientation of the building, and the exposed surface area.

It has been proven that construction costs do not have to be greatly affected in either residential or commercial buildings in order to save energy. An example of this fact in commercial buildings is in the General Service Administration Building in New England. Energy usage is cut between 30-50% by the use of good design. The price came to $50.10 per square foot in comparison with the average cost of $50.00 per square foot for similar construction in that area.

3. EFFECT OF MATERIALS USED

In order to conserve energy in buildings, the principle is to reduce heat transfer through the outer structure of the house. Some building materials allow more heat transfer than others. For example, just as much heat will be lost, or gained, through the same area of 20.3 cm (8 in) of concrete block as through 1.9 cm (3/4 in) of wood and more through a single window pane (Figure 85).

You should consider using combinations of construction materials that will allow the least heat transfer. Table VI gives the relative heat transfer resistance of several common building materials.

As to combinations of these, compare the total resistance to heat transfer of the two wall compositions in Table VII. Note that neither wall has insulation.

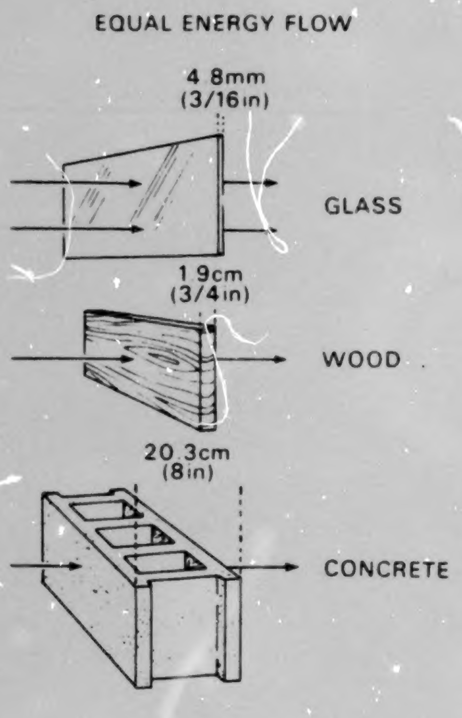

FIGURE 85. Heat loss varies through different materials.

4. EFFECT OF INSULATION

The type, amount and the way insulation is installed are all important in reducing heat transfer in and out of buildings. For example, you may have 15.2 cm (6 in) of insulation in your attic but have more energy loss than your neighbor whose house has the same amount (Figure 86). The reason is that different types of insulation have different insulation values. Another reason is that one house may have all the cracks and crevices covered while the other may not.

You learned from the last section the importance of selecting materials. Note the value of insulation in Table VIII as to resistance to heat transfer.

TABLE VI. RESISTANCE TO HEAT FLOW OF SOME COMMON BUILDING MATERIALS

Type and Material			Resistance to Heat Flow (R)*	
	(cm)	(in)	$\frac{m^2 °C}{W}$	$\frac{h \cdot ft^2 °F}{Btu}$
BUILDING BOARD				
Gypsum	0.95	3/8	0.06	0.32
	1.30	1/2	0.08	0.45
Plywood	0.64	1/4	0.05	0.31
	0.95	3/8	0.08	0.47
	1.30	1/2	0.11	0.62
	1.90	3/4	0.16	0.93
Wood Subfloor	1.90	3/4	0.17	0.94
MASONRY				
Concrete	15.2	6	0.08	0.48
	20.3	8	0.11	0.64
Concrete Blocks 3 oval core sand and gravel	10.2	4	0.13	0.71
	20.3	8	0.20	1.11
Cinder	10.2	4	0.20	1.11
	20.3	8	0.30	1.72
Common Brick	10.2	4	0.14	0.80
Face Brick	10.2	4	0.08	0.44
SIDING				
Wood shingles	41	16	0.15	0.87
Wood bevel	1.3 x 20.3	1/2 x 8	0.14	0.81
Wood plywood	0.95	3/8	0.10	0.59
Aluminum or steel			0.11	0.61
FINISH FLOORING				
Tile, asphalt, linoleum, vinyl, rubber			0.008	0.05
Hardwood			0.010	
ROOFING				
Asphalt 0.95 (3/8)			0.08	0.04
built-up			0.06	0.33

*$\frac{m^2 °C}{W}$ = (meters)^2°C ÷ watts

$\frac{h \cdot ft^2 °F}{Btu}$ = Hours (feet)^2°F ÷ British thermal units

TABLE VII. COMPARISON OF RESISTANCE TO HEAT FLOW OF MATERIALS AND TWO TYPICAL WALL SECTIONS

Frame Wall	Resistance to Heat Flow (R-Value)	
	$\frac{m^2 \cdot °C}{W}$	$\frac{h \cdot ft^2 \cdot °F}{Btu}$
Outside film 24 km/hr (15 mph) wind, winter	0.03	(0.17)
Siding, wood 1.3 x 20.3 cm (1/2 x 8 in lapped)	0.14	(0.81)
Sheathing 1.3cm (1/2 in) regular	0.23	(1.32)
Inside dead air space	0.16	(0.91)
Gypsum wall board 1.3cm (1/2 in)	0.08	(0.45)
Inside surface (winter)	0.12	(0.68)
Total Resistance	0.76	(3.43)

Masonry Wall	Resistance to Heat Flow (R-Value)	
Outside surface 24 km/hr (15 mph)	0.03	(0.17)
Face brick 10.2cm (4 in)	0.08	(0.44)
Cement mortar 1.3cm (1/2 in)	0.02	(0.10)
Cinder block 20.3cm (8 in)	0.30	(1.72)
Air space 1.4cm (3/4 in)	0.23	(1.28)
Gypsum board 1.3cm (1/2 in)	0.08	(0.45)
Inside surface	0.12	(0.68)
Total Resistance	0.86	(4.84)

TABLE VIII. RESISTANCE TO HEAT FLOW OF SOME COMMON INSULATION MATERIALS

Type of Insulation	Resistance to Heat Flow (R-Value)	
	$\frac{m^2 \cdot °C}{W}$	$\frac{h \cdot ft^2 °F}{Btu}$
Blanket and Batt: 5.1-6.9 cm (2-2 3/4 in)	1.23	(7.00)
(fiberglass) 7.6-8.9 cm (3-3 1/2 in)	1.94	(11.00)
13.3-16.5 cm (5 1/4-6 1/2 in)	3.35	(19.00)
Loose Fill:		
Cellulose, per 2.54 cm (in)	0.65	(3.70)
Sawdust, per 2.54 cm (in)	0.39	(2.22)
Perlite, per 2.54 cm (in)	0.48	(2.70)
Mineral fiber (rock, slag, glass)		
7.6 cm (3 in)	1.58	(9.00)
11.4 cm (4 1/2 in)	2.29	(13.00)
16.5 cm (6 1/2 in)	3.35	(19.00)
19.1 cm (7 1/2 in)	2.23	(24.00)
Vermiculite, per 2.54 cm (in)	0.39	(2.20)

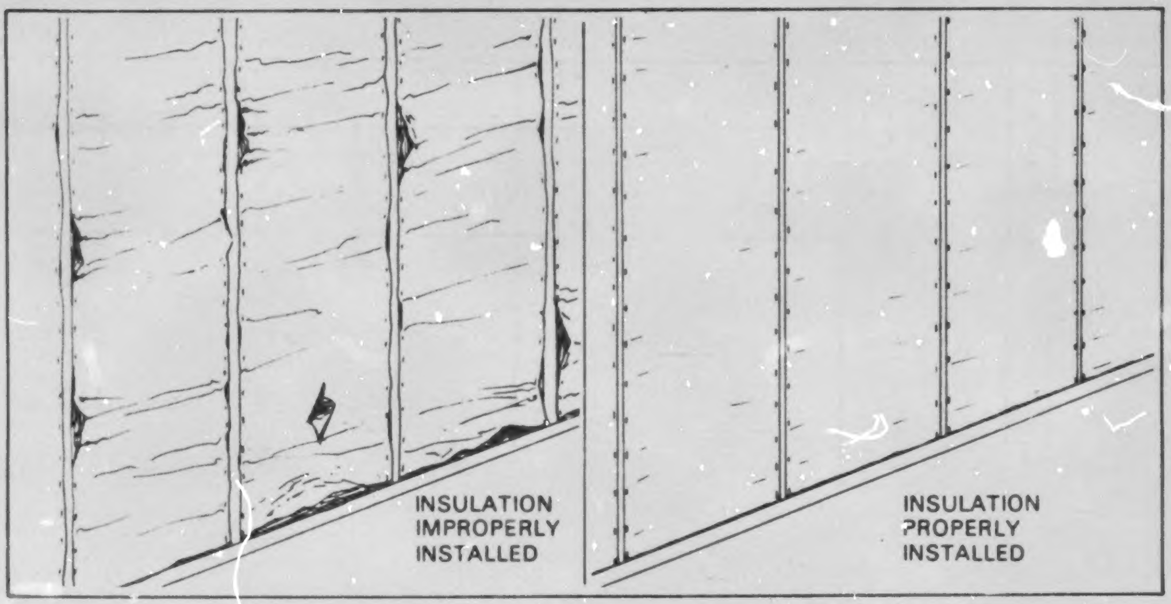
INSULATION IMPROPERLY INSTALLED
INSULATION PROPERLY INSTALLED

FIGURE 86. Two buildings with the same type and thickness of insulation may not have the same energy efficiency.

All types of insulation work on the principle that air is trapped in the spaces between particles or layers of a material. Trapped air is a poor heat conductor. Some insulators combine aluminum foil as a reflector with other insulating material. Aluminum foil reflects heat.

Insulation is available in a variety of forms, sizes and thicknesses. Loose-fill is one of the few types of insulation that can be used to insulate the walls of an existing building without removing the wallboard or plaster (Figure 87).

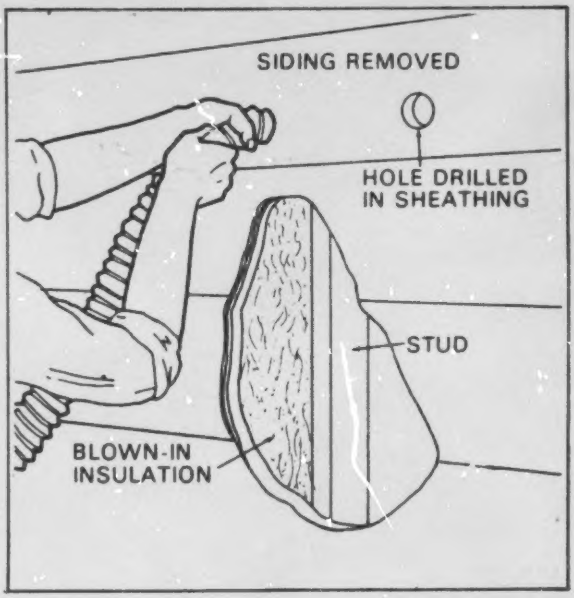
SIDING REMOVED
HOLE DRILLED IN SHEATHING
STUD
BLOWN-IN INSULATION

FIGURE 87. Loose-fill insulation may be blown in.

Loose-fill insulation consists of small particles of mineral wool, wood fibers, or vermiculite. This material can be poured from bags between ceiling joists in an attic, but in walls of existing houses special equipment is required to blow the insulation into the crevices. Adding proper amounts of loose-fill insulation to an uninsulated structure can easily reduce energy consumption by one-half.

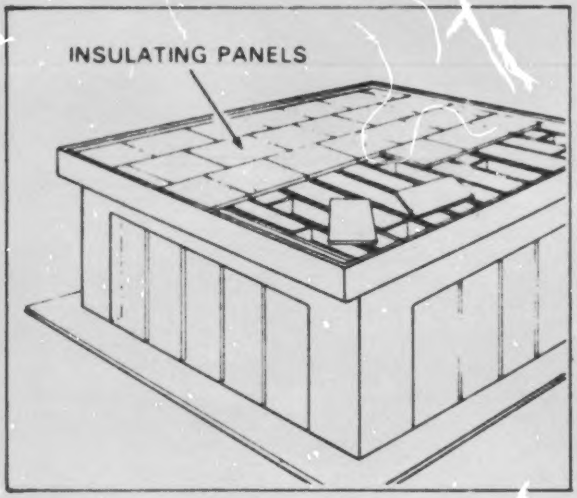

FIGURE 88. Styrofoam and compressed organic fibers come in rigid sheets.

Insulating panels of styrofoam, polyurethane and compressed organic fibers are effective materials when placed in proper locations in buildings (Figure 88). These panels are commonly used on flat roof decks being put in place before the final roofing.

They may also be added to the outside walls.

Flexible insulation is available in blankets and batts. These, too, may be of mineral wool, wood fibers, or fiberglass and come in varying thicknesses (Figure 89). Standard widths are 41 and 61 cm (16 and 24 in). Batt insulation is installed between exterior wall studs and ceiling joists in residences during construction.

5. EFFECT OF VAPOR BARRIERS

As warm air comes in contact with a cooler surface, such as walls and window panes, water vapor in the air condenses on the cooler surface. When insulation is used in walls and ceilings, moisture can condense on the inside surface of the insulation if an extreme temperature difference exists between the room and the outside. If this moisture works its way to the insulation, the insulation becomes a conductor of heat and loses much of its value. To prevent the passage of moisture from the interior of the room to the insulation, a vapor barrier is desirable. This vapor barrier is simply a layer of non-porous paper, plastic, or aluminum foil on the inside surface of the insulating material (Figure 90). Should moisture collect on the vapor barrier, it cannot pass through to the insulation and it eventually evaporates into the room. Thus the insulation in the wall remains dry and effective.

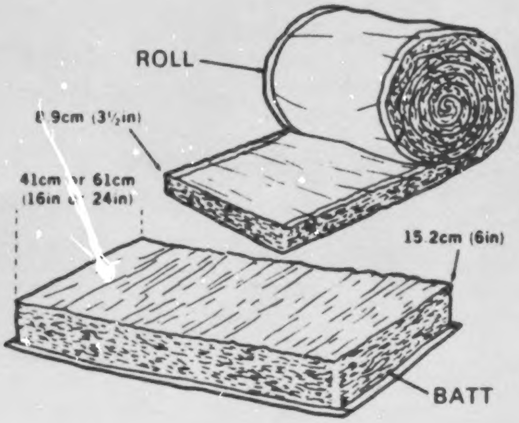

FIGURE 89. Insulation batts or fiberglass.

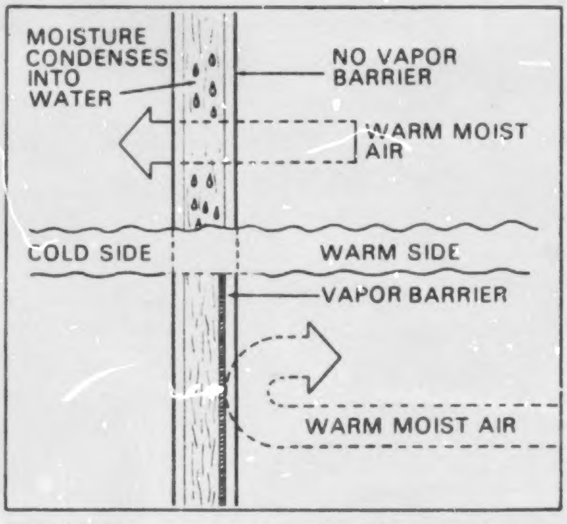

FIGURE 90. A vapor barrier is used to prevent condensation of water on the cool side of your house.

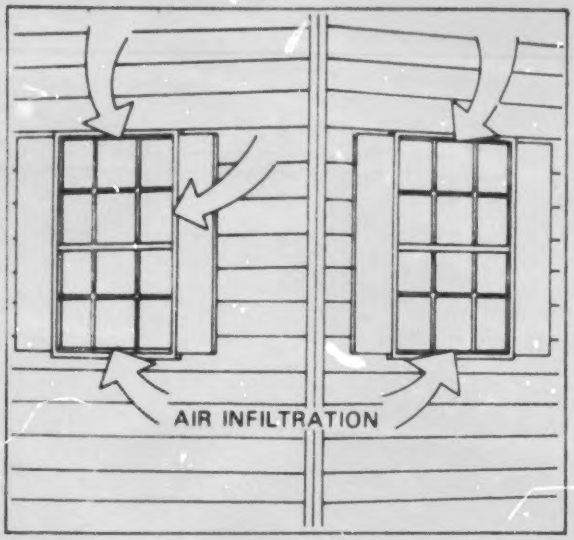

FIGURE 91. Much heat loss and gain in buildings is through air infiltration.

6. EFFECT OF WEATHERSTRIPPING AND CAULKING

Air infiltration is a robber of energy in buildings. No matter how much insulation you have, if there are cracks where cold air can get in, you are going to lose heat (Figure 91).

7. EFFECT OF WINDOWS AND DOORS

Glass is a poor insulator. So the more windows and doors you have, the more heat loss you can expect. For example, a house with several (shaded) windows will lose more energy than one with a few (Figure 92). Windows may be used to an advantage for heat gain if placed on the south side.

Windows and doors are installed to fit loosely enough so that they may be opened and shut with little effort. Therefore, there is always a crack around each window and door through which heat can escape and cold air can blow in. Even if a building is thoroughly insulated and furnished with storm windows and doors, the cracks and openings can add up to a large source of heat loss.

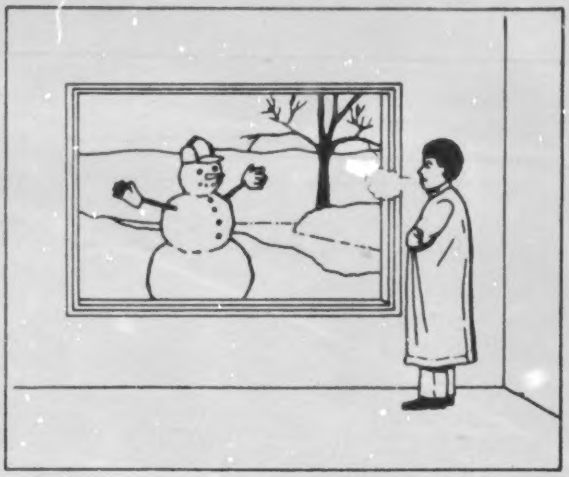

FIGURE 92. Windows have very little resistance to heat flow.

Cold window panes create a draft. The air is cooled by the cold window pane and the colder air sinks toward the floor, allowing the warmer air to move toward the window where it is then cooled. This cooled air also moves toward the floor causing a constant air motion away from the window, at floor level, and toward the window in the upper half of the room. A draft comes from the window and is sometimes confused with a draft blowing through a crack in the frame or between the window sash. Actually this "draft," or air motion, normally occurs although the cracks are sealed.

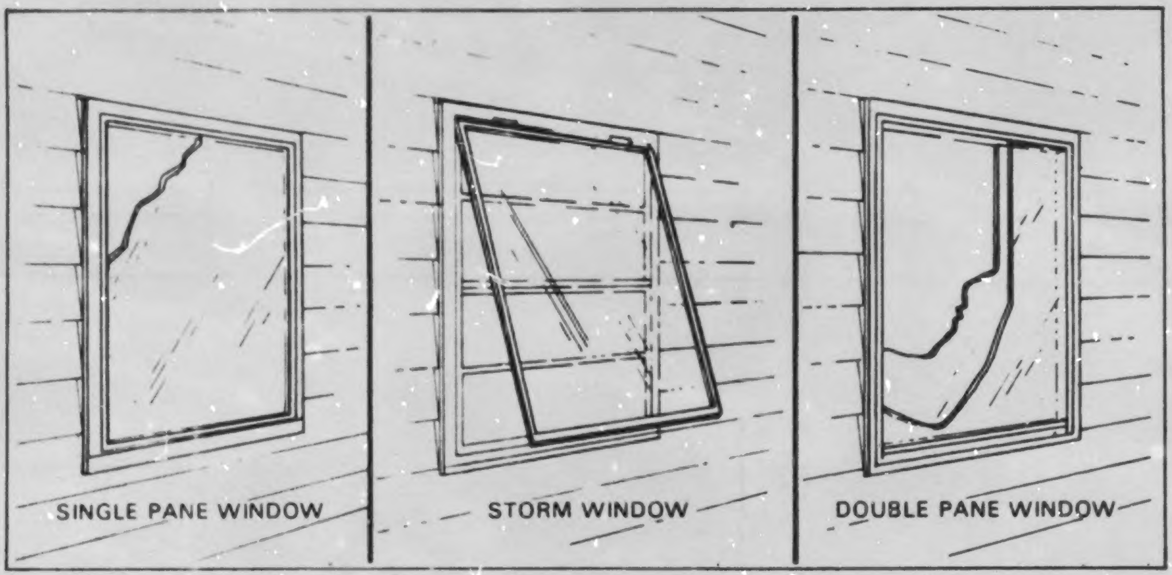
SINGLE PANE WINDOW
STORM WINDOW
DOUBLE PANE WINDOW

FIGURE 93. Storm windows or multi-pane windows save energy.

Storm windows or multi-pane windows help to eliminate this problem (Figure 93). They provide for air space which is resistant to conductive heat flow between two or three panes of glass.

8. EFFECT OF HEATING METHODS

The amount of energy used is directly related to the size of the house (Figure 94). You should consider heating and cooling only part of your home if it is very large.

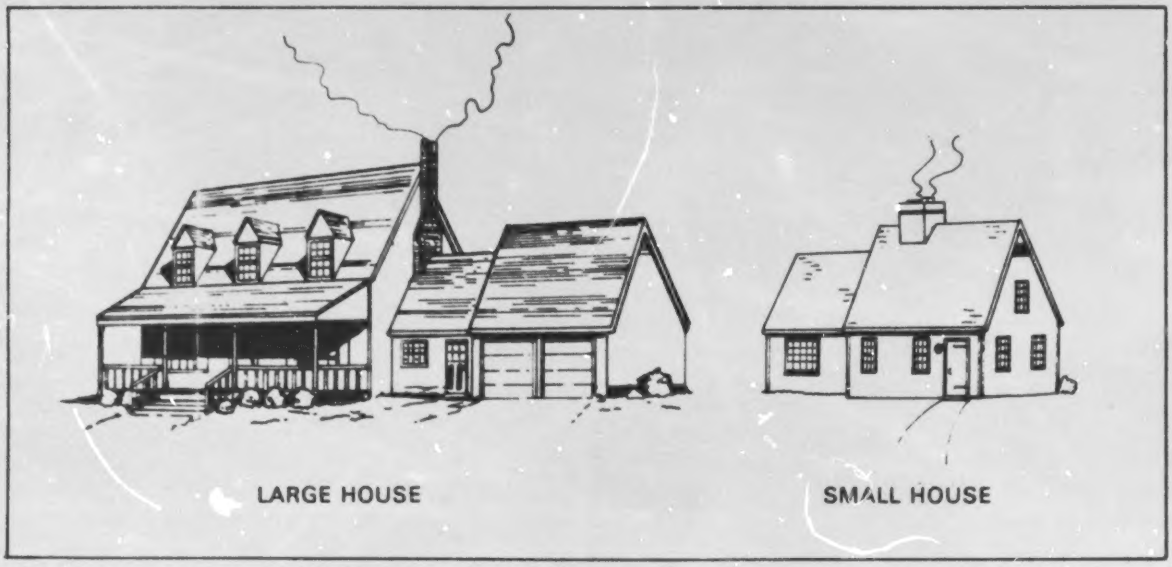
LARGE HOUSE
SMALL HOUSE

FIGURE 94. A large building will naturally use more energy than a small building.

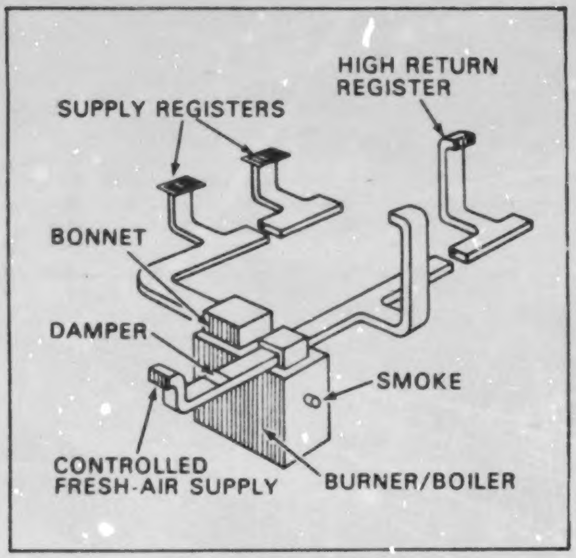
HIGH RETURN REGISTER
SUPPLY REGISTERS
BONNET
DAMPER
SMOKE
CONTROLLED FRESH-AIR SUPPLY
BURNER/BOILER

FIGURE 95. Forced air system.

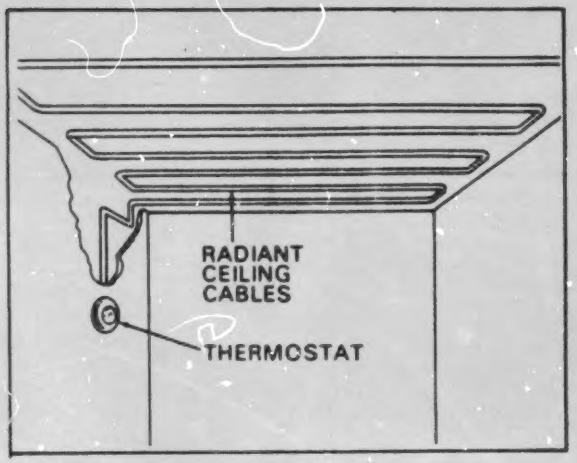
RADIANT CEILING CABLES
THERMOSTAT

FIGURE 97. Electric radiant system.

All heating systems burn fuel, but some are more efficient than others. There is a difference in efficiency of equipment in some systems. But the main consideration is the cost of fuel, which may vary with your locality.

Heating systems generally used are as follows:

- Forced air (Figure 95).
- Hot water (hydronic) (Figure 96).
- Electric radiant (Figure 97).
- Electric resistance (Figure 98).
- Heat pump (Figure 99).
- Fireplace (Figure 100).
- Stove (Figure 100).

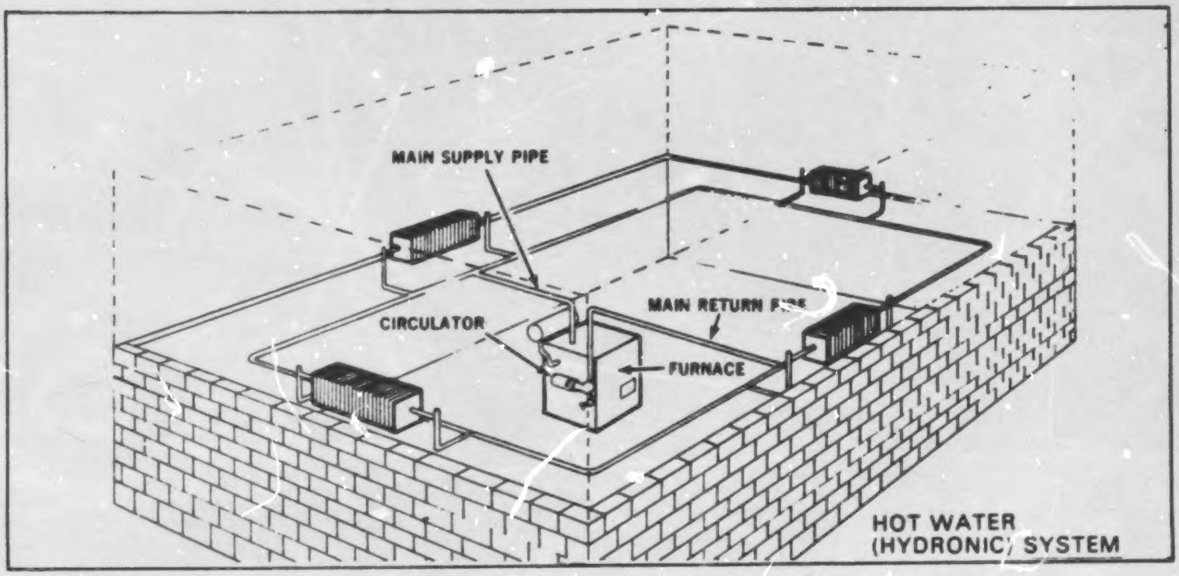
MAIN SUPPLY PIPE
MAIN RETURN PIPE
CIRCULATOR
FURNACE
HOT WATER (HYDRONIC) SYSTEM

FIGURE 96. Hot water (hydronic) system.

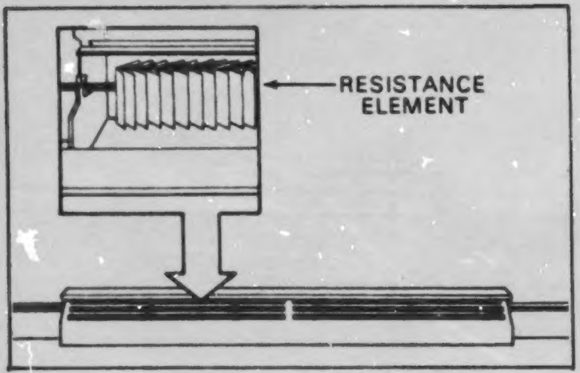
RESISTANCE ELEMENT

FIGURE 98. Electric resistance system.

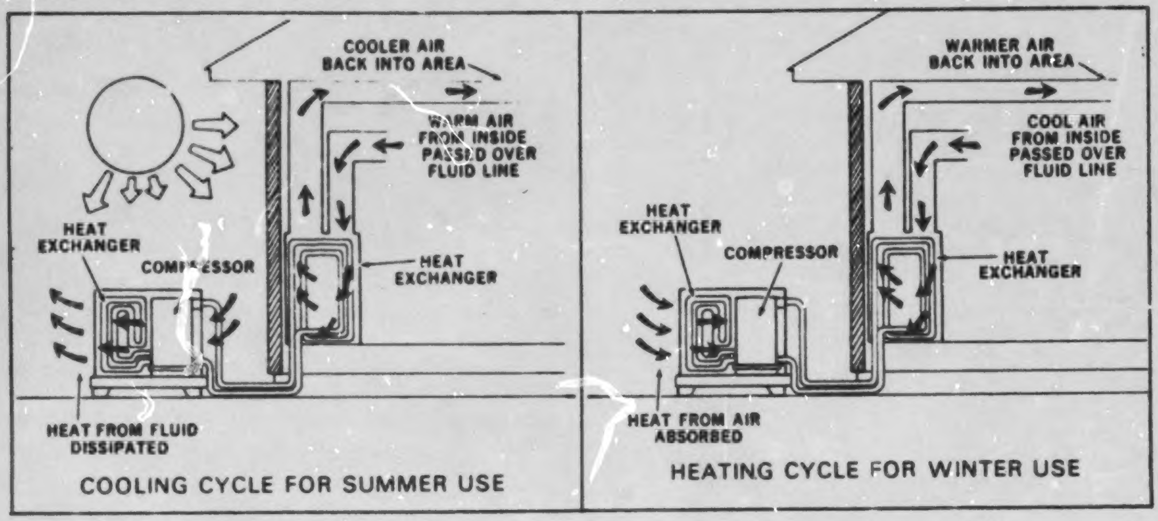
COOLER AIR BACK INTO AREA
WARM AIR FROM INSIDE PASSED OVER FLUID LINE
HEAT EXCHANGER
COMPRESSOR
HEAT EXCHANGER
HEAT FROM FLUID DISSIPATED
COOLING CYCLE FOR SUMMER USE
WARMER AIR BACK INTO AREA
COOL AIR FROM INSIDE PASSED OVER FLUID LINE
HEAT EXCHANGER
COMPRESSOR
HEAT EXCHANGER
HEAT FROM AIR ABSORBED
HEATING CYCLE FOR WINTER USE

FIGURE 99. Heat pump.

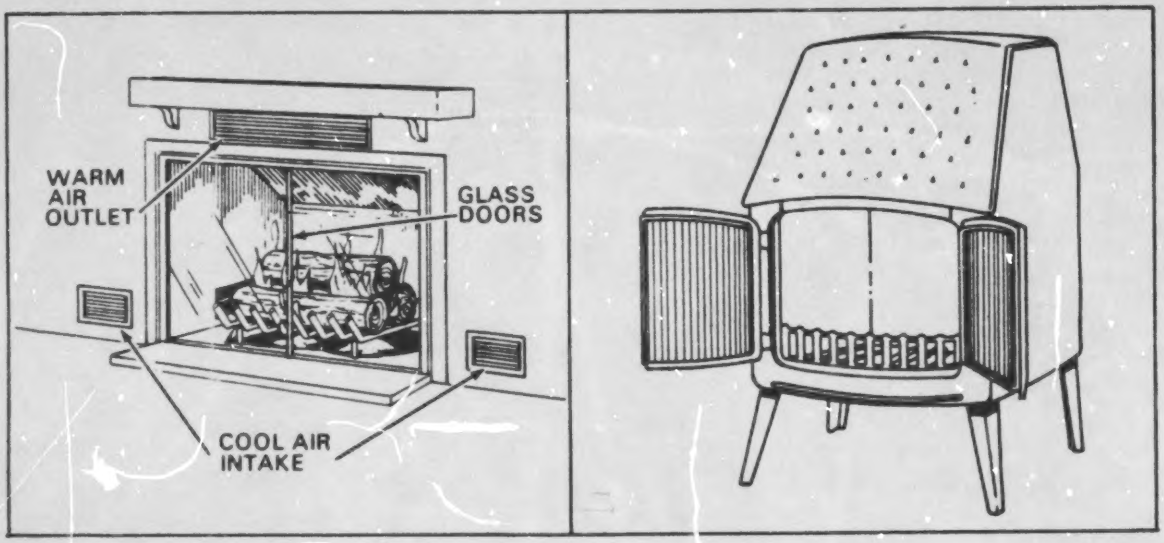
WARM AIR OUTLET
GLASS DOORS
COOL AIR INTAKE

FIGURE 100. Fireplace and stove.

9. EFFECT OF AIR CONDITIONING

If you live in a temperate zone, you can expect to use about as much energy to cool your house as you do to heat it (Figure 101). Here you are trying to prevent heat on the outside from becoming equal to the temperature on the inside.

The same insulation is required. But direct sun light should be shaded from windows.

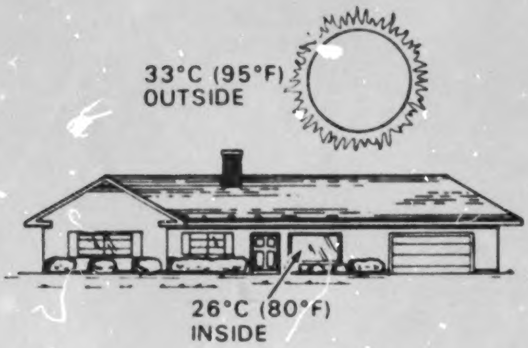
33°C (95°F)
OUTSIDE
26°C (80°F)
INSIDE

FIGURE 101. In some areas, it takes as much energy to cool a house in summer as to heat it in winter.

More and more, Americans are regarding air conditioning as a necessity, rather than a luxury. Even though air cooling is only 3% of the total national energy consumption, in the hot months it rises to about 42% of total energy consumption.

10. EFFECT OF VENTILATION METHOD

A certain amount of ventilation is required in a home. One reason is for comfort. Another is for cooling in summer. Particularly the attic should have an air exchange (Figure 102). Temperatures in attics may get as high as 60°C (140°F).

11. NEW METHODS OF HEATING AND COOLING

Passive solar systems are helping to reduce energy consumption.

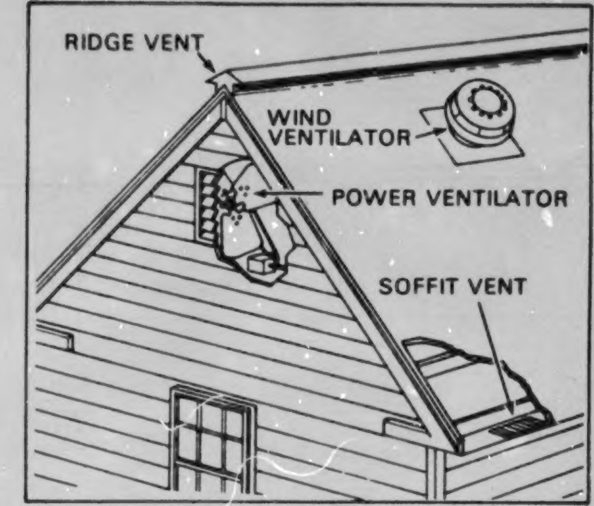
RIDGE VENT
WIND VENTILATOR
POWER VENTILATOR
SOFFIT VENT

FIGURE 102. Attic cooling vents will save energy in summer.

12. EFFECT OF LIGHTING

Most of the energy used by lighting is in the form of heat. Since lights do supply some heat during winter, it is not so important to turn them off. But in summer, heat from lights works against the air conditioning system.

You can save energy by planning your lighting so that it is the most efficient (Figure 103). Fluorescent lights give more light for energy used than incandescent lights.

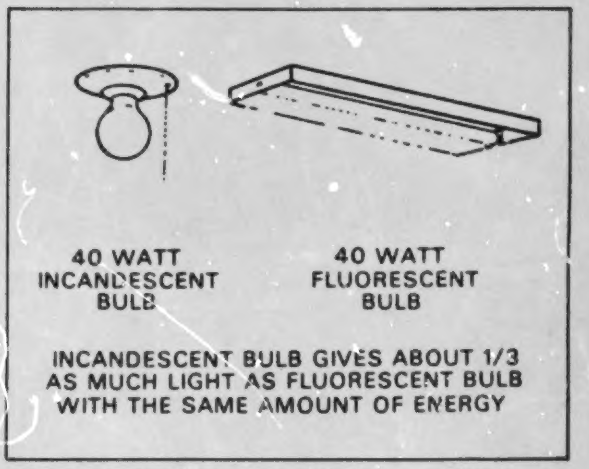
40 WATT INCANDESCENT BULB
40 WATT FLUORESCENT BULB
INCANDESCENT BULB GIVES ABOUT 1/3 AS MUCH LIGHT AS FLUORESCENT BULB WITH THE SAME AMOUNT OF ENERGY

FIGURE 103. Plan an efficient lighting system to save energy.

13. EFFECT OF PLUMBING

Plumbing can be designed to save energy. Dripping faucets lose energy, especially hot water faucets. It is usually not cost effective, however, to insulate residential pipes.

A water heater located inside the living area will help heat the house but will work against the air conditioning in summer (Figure 104). In any case, the water heater should be well-insulated.

When adding insulation to gas heaters, be sure to provide for air to the burner.

14. ENERGY-EFFICIENT APPLIANCES

Much emphasis is now being placed on the operating efficiency of appliances. When purchasing new appliances, you should compare efficiencies.

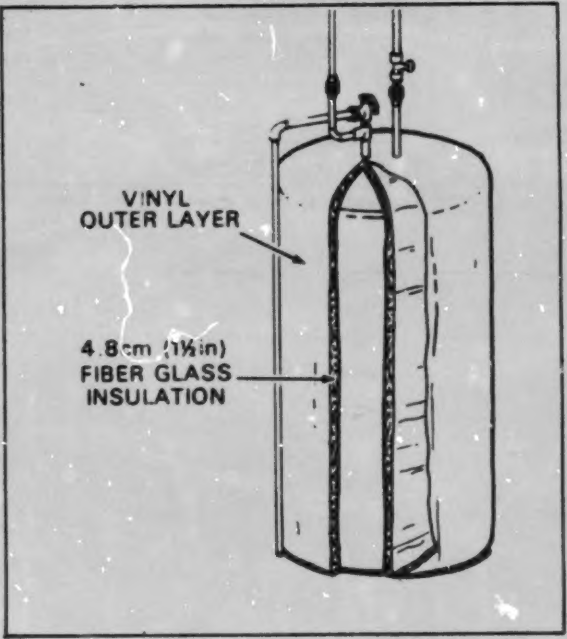

FIGURE 104. Water heaters should be well-insulated.

General Recommendations for Energy Efficiency in Residences

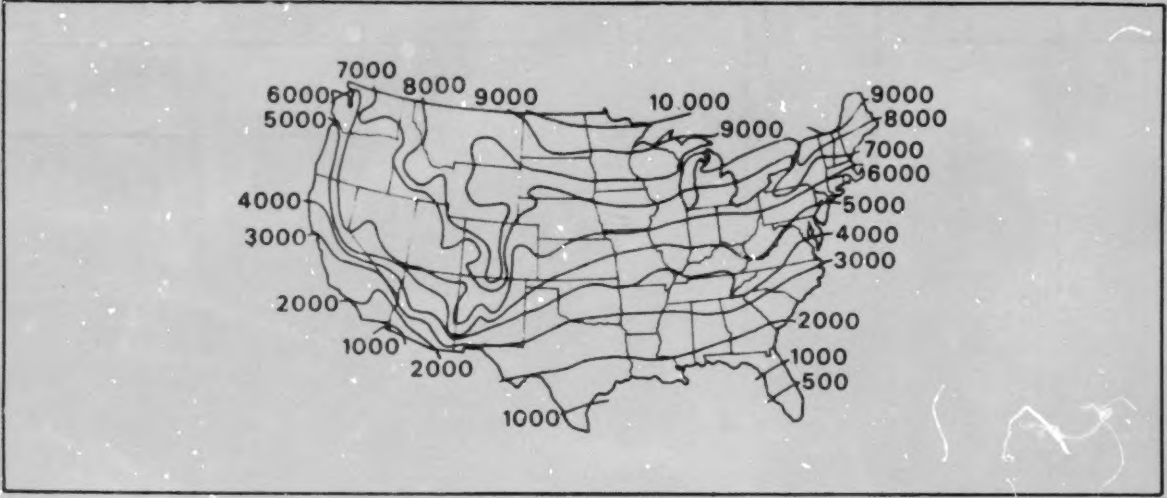

FIGURE 105. Winter degree days for different geographic locations.

General recommendations for improving the energy efficiency in your home are as follows:

1. Caulk all cracks and joists.
2. Weatherstrip all doors and windows.
3. Insulate heating and ventilating pipes and ducts if they are in unconditioned space.

   Use R_2 for pipes and R_4 for ducts.
4. Provide outside combustion air to all fossil fuel burners.

   This includes wood stoves and fireplaces.
5. Fit fireplaces with a glass-front seal.
6. Use only high-efficient heating, air conditioning and appliances. Heating systems should not be designed for greater than 15% oversize. EER ratings should be 8 or above.
7. Find winter degree days for your locality (Figure 105).

   For more specific information, contact your Energy Extension Office.
8. Select type of heating fuel you are using in column 2, Table IX.
9. Find R-value recommended for ceilings, walls and floors for your type of windows and doors.
10. Follow procedures in Parts Two and Three for computing more accurately the heat loss and gain and selecting and installing materials.

WAYS AND MEANS OF REDUCING HOME AND SMALL BUILDING ENERGY USE

IP-3. Strategies and Techniques for Reducing Residential and Commercial Energy Consumption

OBJECTIVE

This instructional package will help identify strategies that may be used to reduce energy consumption in small buildings and homes. When finished with this instructional package, you will be able to:

A. Identify major means for reducing residential and commercial energy consumption.

B. List strategies for reducing residential and commercial energy consumption.

RESOURCES

Book:

Home Energy Conservation Primer. Vogel, Michael. Morgantown, West Virginia: West Virginia University, 1980.

Information Sheet:

Strategies and Techniques for Reducing Residential and Commercial Energy Consumption, 1980, IP-3,1-19.

ACTIVITY

A. Review instructional package resources listed on previous page.

B. List five (5) strategies for reducing energy use under each of the categories listed below:

Minor Appliances

1.
2.
3.
4.
5.

Heating System

1.
2.
3.
4.
5.

Lighting

1.
2.
3.
4.
5.

Laundry Appliances

1.
2.
3.
4.
5.

Landscaping

1.
2.
3.
4.
5.

Coding System

1.
2.
3.
4.
5.

Hot Water System

1.
2.
3.
4.
5.

Cooking

1.
2.
3.
4.
5.

ACTIVITY (Continued)

Refrigeration Systems	Building Structure
1.	1.
2.	2.
3.	3.
4.	4.
5.	5.

C. Check your responses with your instructor.

FEEDBACK

Objective A-B Check:

Check your responses with your instructor.

____
Instructor's Approval

Strategies and Techniques for Reducing Residential and Commercial Energy Consumption

Energy conservation is on the rise in many households and commercial buildings. Industry data show that 2-3 million households added an average of 4-5 inches of attic insulation during 1974, 1975, and 1976. Reports in 1977 suggest a figure of nearly 6 million. Adding 4-5 inches of attic insulation cuts space heating needs by 10-20 percent, depending upon local climate and the condition of the house.

Occupants of 10 million single family detached homes (22% of the applicable housing stock) took action to add energy-saving features in 1975. The average household spent $150 for attic insulation, wall insulation, storm doors, storm windows, caulking, and/or weatherstripping.

The number of new heat pumps installed in homes increased rapidly from 61,000 in 1971 to 250,000 in 1976, doubling between 1975 and 1976. Heat pumps provide winter heating with approximately 60% of the electrical energy required by electric resistance systems. This increase in sales is particularly significant because the initial investment is several hundred dollars more than for a conventional system supplying electric resistance heat and central air conditioning.

There are many examples of individual schools, hospitals, and stores whose "housekeeping" changes have produced large energy savings. A large office building in Los Angeles, for example, cut energy use 45% with lower lighting levels, lower thermostat settings for winter and higher ones for summer, and improved controls on heating-cooling ventilation systems.

Federal programs have had a major impact on energy use in buildings through federal energy legislation. Although federal energy policy is still evolving, there already exists a substantial amount of energy legislation that has profound includes the Energy Policy and Conservation Act (EPCA), the Energy Conservation and Production Act (ECPA) of 1976, and the National Energy Act (NEA) of 1978.

The stated purpose of both of 1975 and 1976 acts is to increase the supply of domestic energy through productive incentives while restraining energy demands through greater conservation. The provisions of both acts are highlighted in Table 1.

1 P-3, 1-2

GOVERNMENT ENERGY POLICIES

Substantial legislation already exists dealing with energy. At the Federal level most of this legislation is aimed at curtailing energy consumption; at the state level much of it encourages the use of solar energy; and at the local level the emphasis is on building codes. Regardless of level, parts of this legislation are generating real estate market changes.

Existing Federal Energy Legislation

Although Federal energy policy is still evolving, there already exists a substantial amount of energy legislation that has profound effects on the real estate professional. Specifically, this legislation includes the Energy Policy and Conservation Act (EPCA) of 1975, the Energy Conservation and Production Act (ECPA) of 1976, and the National Energy Act (NEA) of 1978.

EPCA and ECPA

The stated purpose of both the 1975 and 1976 Acts is to increase the supply of domestic energy through production incentives, while restraining energy demand through greater conservation. The provisions of both Acts are highlighted in Table II-1. The production incentives section of the 1975 Act rolled back the maximum price for newly

TABLE II-1. HIGHLIGHTS OF EPCA AND ECPA

A. Highlights of EPCA (1975)

1. Domestic Supplies and Strategic Petroleum Reserve
   - incentives for coal conversion
   - export restrictions
   - prohibition of certain lease building arrangements
   - production rate requirements (oil and natural gas)
   - reserves of up to 1 billion barrels

2. Standby Energy Authorities
   - energy conservation and rationing contingency plans
   - export restrictions

3. Improving Energy Efficiency
   - automotive fuel economy (27.5 mph by 1980)
   - consumer product labeling
   - consumer product energy efficiency standards
   - consumer education

     A. State Energy Conservation Plans
        - fines required plus supplemental programs to achieve 5 percent or more reduction in projected 1980 statewide energy consumption
        - Federal assistance to states

     B. Industrial Energy Conservation
        - voluntary reporting
        - individual industry targets

     C. Other Measures
        - Federal energy conservation program
        - recycling of oil

4. Petroleum Pricing Policy and Amendments to the Allocation Act

5. General Provisions
   - energy data base

B. Highlights of ECPA (1976)

1. FEA Amendments
   - extended lifetime of FEA
   - enhanced EPAA (1973)
   - created Office of Energy Information and Analysis

1 P-3, 1-4

TABLE II-1. HIGHLIGHTS OF EPCA AND ECPA (Continued)

2. Electrical Utility Rate Design Initiatives
   - load management
   - marginal-cost or time-of-day pricing

3. Energy Conservation Standards for New Buildings (performance type)
   - NBS, NIBS, and HUD to develop by 1980
   - Federal financial assistance cutoff to areas that do not adopt and implement standards

4. Energy Conservation and Renewable Resource Assistance for Existing Buildings
   - weatherization assistance for low-income persons
   - supplemental state energy conservation plans--public education, intergovernmental coordination, and energy audits required
   - energy conservation and renewable resources demonstration program for existing buildings
   - grants, low-interest loans, interest subsidies, and loan guarantees to encourage energy-saving retrofitting
   - loan obligation guarantee program for commercial buildings

Adapted from Department of Energy, Organization and Functions Fact Book, (Washington, D.C., 1977) discovered oil to $7.60 a barrel, but gave the President authority to raise the price a maximum of 3 percent per year in order to encourage production. Although a price rollback usually stimulates consumption and thus tends to aggravate a shortage, the rollback in the 1975 Act was envisioned as a production incentive.

Dissatisfied with the effect of the 1975 Act, in the 1976 Act Congress encouraged the President to increase the price of newly discovered oil by as much as 10 percent per year. Additional price incentivies for increased production include the elimination of price controls on crude oil from stripper wells and the recommendation that the President provide price incentives for various enhanced recovery techniques.

Impact on Real Estate Professionals

The 1975 and 1976 Acts also directly and indirectly affect the business expenses and the information utilized by real estate professionals. To encourage energy conservation, the 1975 and 1976 Acts include product labeling requirements, product efficiency standards, and consumer education programs.

The 1975 Act mandates labeling a variety of products with their energy efficiency ratings. Just as all automobiles must now carry labels indicating their fuel economy, their estimated annual fuel costs, and the range of fuel economy for comparable vehicles, many household appliances will also have energy efficiency labels. Because efficiency-labeled products are often included in the real estate transaction, the real estate professional needs to be knowledgeable about their energy efficiency ratings (EER).

1 P-3, 1-6

The National Energy Act (NEA) was by the 95th Congress on October 15, 1978, and includes five separate bills. Provisions of the NEA are expected to result in reduced imports by 1985, increased usage of fuels other than oil and gas, and more efficient and equitable use of energy in general. The five bills of the Act are these:

1. P.L. 95-617: The Public Utilities Act
2. P.L. 95-618: The Energy Tax Act
3. P.L. 95-619: The National Energy Conservation Policy Act (NECPA)
4. P.L. 95-620: The Powerplant and Industrial Fuel Use Act
5. P.L. 95-621: The Natural Gas Policy Act

The stated purpose of these bills is to put in place a policy framework for decreasing oil imports, and it is estimated that full implementation of these bills will save at least 2.5 million barrels of imported oil per day by 1985.

Technical changes in the residential/commercial sector could lead to a more than 40 percent reduction in its fuel requirements. A careful look at the energy actually used by homes and commercial buildings in 1973 suggests a wide array of specific opportunities for energy efficiency improvements. The more important technical improvements include:

- Reduce heating losses by 50 percent with better insulation, improved windows and reduced infiltration; this reduction is the single most important step in this sector accounting for about one-half of the savings.
- Substitute heat pumps for electric resistance heating.
- Cut water heating fuel requirements by 50 percent through the addition of more insulation, reduced hot water temperature settings, and the use of solar energy or heat recovery from other appliances.
- Increase the efficiency of new air conditioners and refrigerators, and introduce total energy systems.
- Improve lighting systems to reduce energy requirements for lighting in commercial buildings by 50 percent.

The possibility of making these improvements has been well documented. For example, it has been shown that energy consumption by refrigerators and air conditioners varies over a remarkably wide range. In the case of refrigerators energy use can vary by a factor of two within a single class of size and features with little correlation between energy requirements and first cost. In addition to the opportunities for more efficient appliances and space heating systems, the energy characteristics of most buildings themselves can be vastly improved. New buildings can be economically designed to reduce typical space heating requirements by 75 percent, with similar savings achievable in many older buildings.

1P-3,1-8

Potential Annual Fuel Savings in the Residential Sector
(percent of 1973 total energy demand)

Conservation Measures	Potential Savings
Replace resistive heating with heat pumps	0.8
Increase air-conditioner efficiency	0.5
Increase refrigerator efficiency	0.4
Cut water heating fuel requirements	1.4
Reduce heat losses	4.4
Reduce air conditioner load by reducing infiltration	0.6
Introduce total energy systems into 1/2 multifamily units	0.4
Use microwave ovens for 1/2 of cooking	0.3
Total	8.8*

Potential Annual Fuel Savings in the Commercial Sector
(percent of 1973 total energy demand)

Conservation Measures	Potential Savings
Increase air-conditioner efficiency	0.5
Increase refrigeration efficiency	0.3
Cut water heating fuel requirements	0.4
Reduce building lighting energy	1.3
Reduce heating requirements	3.0
Reduce air-conditioner demand with better insulation	0.1
Reduce air-conditioning demand by reducing ventilation rate and by using heat recovery apparatus	0.1
Use total energy systems in 1/3 of all units	0.9
Use microwave ovens for 1/2 of cooking	0.1
Total	6.6*

*Totals may not add due to rounding

Source: Adapted from M.H. Ross and R.H. Williams, "Energy and Economic Growth," published in Achieving the Goals of the Employment Act of 1946--Thirtieth Anniversary Review (Washington, D.C.: U.S. Government Printing Office, 1977).

Attic and wall insulation can be increased. Storm windows, storm doors, and weatherstripping can be added. The efficiency of heating and cooling can be raised through the increased use of heat pumps instead of electric resistance heating and by the substitution of improved air conditioners and oil and gas furnaces. And new homes can be built with many "passive solar" features such as overhangs, large southern exposures, and moveable insulated window panels.

These are only a few of the conservation strategies available to homeowners. It is the primary purpose of this other modules in this series to treat each of these and additional strategies in detail. The following

check list [illegible] additional) [illegible]

1P-3, 1-9

Exhibit 8.4 Building Checklist

1. Shade walls and paved areas adjacent to the building to reduce solar radiation striking the building.
2. Plant deciduous trees for their summer sun shading and windbreak effects for building up to three stories.
3. Plant coniferous trees for summer and winter sun shading and windbreak effects.
4. Cover exterior walls with planting to reduce heat transmission and solar gain, taking care that the planting will not have deleterious effects on the building material.
5. Plant shrubs or lawn between the building perimeter and sidewalk to reduce heat built-up.
6. Plant lawn between sidewalk and the street to reduce heat build-up, if maintenance is possible in view of the amount of foot traffic.
7. Consolidate or, where feasible, relocate paved areas away from the building perimeter and replace with grass or other vegetation to reduce outdoor temperature build-up.
8. Use ponds and water fountains to reduce ambient outdoor air temperature around building.
9. Use carpeting for thermal comfort particularly over slabs on grade.
10. Do not heat parking garages.
11. Reduce crack areas around doors, windows, etc., to a minimum.
12. Provide all external doors with weatherstripping.
13. Be sure operable windows have sealing gaskets and cam latches.
14. Provide all entrances with unheated and uncooled vestibules or revolving doors when not in conflict with public law and fire safety requirements.
15. Provide vestibules with self-closing weatherstripped doors to isolate them from the stairwells and elevator shafts.
16. Seal all vertical shafts.
17. Provide windbreaks for ventilation louvers.
18. Provide exterior shades that eliminate direct sunlight but reflect light into occupied spaces.
19. Slope vertical wall surfaces so that windows are self-shading and walls below act as light reflectors.
20. Use clear glazing. Reflective or heat absorbing films reduce the quantity of natural light transmitted through the window.
21. In climatic zones where outdoor air conditions are suitable for natural ventilation, provide operable windows. Where applicable, allow cross-ventilation through occupied spaces.
22. Where codes or regulations require operable windows and infiltration is undesirable, use windows that close against a sealing gasket.
23. To reduce air infiltration quantities, consider one or more of the following measures:
    a. Be sure fixed glass facades are adequately gasketed and/or caulked.
    b. If possible, use permanently sealed windows to reduce infiltration in climate zones where this is a large energy user.
24. To minimize heat gain in summer due to solar radiation, consider one or more of the following:
    a. Finish roofs with a light colored surface having high emissivity.
    b. Convert to reflective surfaces.
    c. Install roof sprays.
    d. Install roof ponds.

1P-3, 1-10

Exhibit 8.4
(Continued)

25. To allow the use of natural light in cold zones where heat losses are high energy users, consider operable thermal barriers.
26. To take advantage of natural daylight within the building and reduce electrical energy consumption, consider the following:
    a. Increase window size but do not exceed the point where yearly energy consumption, due to heat gains and losses, exceeds the savings made by using natural light.
    b. Locate windows high in wall to increase reflection from ceiling, but reduce glare effect on occupants.
    c. Control glare with translucent drapes operated by photo cells.
    d. Sun controls are most effective when designed for each specific orientation. Horizontal shading devices, such as awnings, prevent solar gains when installed on southern exposures. On east and west walls, a combination of horizontal and vertical devices are needed to prevent solar gains. Vertical sun controls might simply be trees and shrubs.
    e. Venetian blinds act as adjustable solar screens and can cut solar gains considerably.
    f. Closed draperies are sometimes more effective in controlling solar gains than tinted glass.
    g. Exterior louvered solar screens, as well as interior shutters, can prevent excessive heat loss in addition to controlling solar gains. Shutters can be equipped with devices to seal windows at a preset time or temperature.
    h. Color is important in all of the above treatments. Where cooling is a problem, venetian blinds and the inside and outside of shutters should be light in color to reflect heat and light away from the building. Where heating and/or light restriction are desired, the use of dark draperies or dark shades is sensible.
27. Shelter service areas from sun and wind with screens and walls and/or by judicious planting of trees.
28. Consider enclosing service and delivery areas with power-operated doors.
29. Provide options such as covered personnel loading and unloading sites at building if such options will encourage car-pooling or use of mass transit.
30. Evaluate the trade-offs between heat loss and heat gain on each exposure with particular regard to the wind and the sun.
31. Evaluate the utilization of daylight versus heat loss and heat gains and glare problems peculiar to each exposure.
32. Evaluate the beneficial effects of direct solar radiation for heating versus the adverse effects during the cooling season.
33. Evaluate the extent to which alteration of the building envelope would maximize energy conservation benefits when evaluating all the trade-offs.
34. Consider insulation with low water absorption that dries out quickly and returns to its original thermal performance.
35. Protect insulation from moisture originating outdoors, since efficiency decreases when the insulation is wet.
36. Provide vapor barriers in exterior walls and roof of sufficient impermeability to prevent condensation. Vapor barriers are required on the interior surface or exterior walls for heating and on both interior and exterior walls for cooling (with ventilation in between).
37. Locate insulation at the exterior surface for walls, roof, and floors over garages.

1 P-3, 1-11

Exhibit 8.4
(Continued)

38. If possible, insulation should be located not only on the outside surface of a wall section, but also on the outside of the structure itself.
39. Where floors are over unheated spaces, such as a garage, consider suspending a ceiling beneath the open floor beams with batt insulation. .
40. In cool and cold climates, consider adding perimeter insulation to floors on grade. This can sometimes be added vertically to the grade beams.
41. Consider the use of the insulation type which can be most efficiently applied to optimize thermal resistance of the wall or roof.
42. Avoid thermal bridges through the exterior surfaces.
43. Provide textured finish to external surfaces to increase the external film coefficient.
44. Reduce heat transmissions through the roof by one or more of the following methods:
    a. Increase insulation.
    b. Provide sod and planting. .
    c. Add a double roof and ventilate space between.
45. To minimize heat gain in summer due to solar radiation, finish walls and roof with a light-colored surface having high emissivity.
46. To reduce heat loss through glass windows, consider one or more of the following:
    a. Reduce the ratio of glass wall and window area to opaque wall area.
    b. Reduce percentage of glazing to a minimum on north wall.
    c. Allow direct sun on windows from November through March.
    d. Convert to double glazing.
    e. Convert to triple glazing.
    f. Replace window frames that form a thermal bridge.
47. To reduce heat gain through glass, consider one or more of the following:
    a. Reduce the ratio of glass wall and window area to opaque wall area.
    b. Convert to double glazing.
    c. Convert to triple glazing.
    d. Consider double glazing with a reflective surface.
    e. Reduce percentage of exposed window glazing on the south wall.
    f. Shade windows from direct sun from April through October.
    g. Use venetian blinds or drapery as interior shading devices.
48. Consider the use of solar controls, such as internal or external shading devices to manipulate sunlight and achieve the maximum advantage and energy savings from it.
    a. Solar shading devices used to reduce heat gain in the summer are most effective when located on the exterior of the building and particularly effective when movable.

1P-3, 1-12

Exhibit 8.7 Lighting Checklist

1. Design lighting for the task.
2. Provide the required illumination for visual tasks in the working areas only and appropriate lower levels in the general areas, such as corridors, storage, and circulation areas.
3. Reduce the wattage required for each specific task by review of user needs and method of providing illumination.
4. Consider only the amount of illumination required for the specific task in view of the duration, the character, and the user performance required.
5. Group similar tasks together for optimum conservation of energy per floor.
6. Illuminate tasks with fixtures built into furniture and maintain low intensity lighting elsewhere.
7. Consider wall washers and special illumination for features such as plants and murals, in place of overhead lighting to maintain proper contrast ratios.
8. For horizontal tasks or duties consider fixtures whose main lighting component is oblique and then locate for maximum ESI footcandle on task.
9. Avoid decorative flood lighting and display lighting.
10. Use fixtures that give high contrast rendition at task.
11. Reduce lighting requirements for hazards by:
    - a. Use of light fixtures close to and focused on hazard.
    - b. Increased warning of hazards; i.e., paint stair treads and risers white with black nosings.
12. Keep exterior lighting to a minimum by consideration of the following:
    - a. Eliminate exterior lighting except where lighting is to be used for the purpose of identifying the building entrances and/or for security.
    - b. Consider intruder-activated devices rather than photo- or time-controlled illumination security luminaires.
    - c. Coordinate street lighting with security lighting and eliminate duplication.
    - d. Use high-efficiency light sources (high-pressure sodium or HID lamps).
    - e. Use efficient luminaires (prismatically controlled lens, rather than general diffuse or decorative geometric forms).
    - f. Use photo cells for turning on exterior lights and time clocks for turning off the exterior lights.
13. Consider the use of ballasts which can accommodate sodium metal-halide bulbs interchangeably with other lamps.
14. Select the most efficient light sources.
15. Consider using 250-watt mercury vapor lamps and metal-halide lamps in place of 500-watt incandescent lamps for special applications.
16. Use lamps with higher lumens per watt input such as:
    - a. One 8-foot fluorescent lamp versus two 4-foot lamps.
    - b. One 4-foot lamp versus two 2-foot lamps.
    - c. U-tube lamps versus two indivudal lamps.
    - d. Fluorescent lamps in place of all incandescent lamps except for very close task lighting, such as for a typewriter.
17. Consider the use of landscape office planning to improve lighting efficiency. Approximately 25% less wattage per footcandles on tasks is possible by the use of open planning versus partitions.

1 P-3, 1-13

Exhibit 8.7
(Continued)

18. Consider the use of light colors for walls, floors, and ceilings to increase reflectance (but avoid specular reflections).
19. Lower the ceilings or mounting height of luminaires to increase the level of illumination with less wattage.
20. Select furniture and interior appointments that do not have glassy surfaces or give specular reflections.
21. Avoid the use of glossy surfaces on the task and its surroundings.
22. Use high reflectance finishes on room surfaces (particularly vertical surfaces).
23. Lay out the luminaires for visual performance rather than uniform space geometry.
24. Within the limits of the luminaire supporting system, locate the luminaires as close to directly over the task as possible without creating excessive reflections.
25. Locate luminaires just beyond the ends and working edge of the desk. Avoid locating luminaires directly in front of the visual task.
26. In multiple task areas, luminaires should be located between the desks so that the main lighting components originate from either or both sides of the desk.
27. Provide proper controls for the luminaires.
28. Install switches for lights near the windows so the lights may be turned off in accordance with the amount of daylight available at any given time.
29. Luminaires should be selectively switched according to possible grouping of working tasks at different working hours.
30. Use multiple lamp luminaires so that one lamp may be switched off during different times of the day.
31. Design switch circuits to permit turning off unused or unnecessary lights.
32. Evaluate the use of low voltage (24 volts or lower) switching systems to obtain maximum switching capability.
33. Provide timers to turn off lights automatically in remote or seldom used areas.
34. Utilize daylight.
35. Use natural illumination in areas when a net energy conservation gain is possible vis-a-vis heating and cooling loads.
36. Provide exterior reflectors at windows for more effective internal illumination.
37. Use thermally controlled luminaires.
38. When space and codes permit, use luminaires which will allow room air to flow through the lamp compartment. When supply air can be discharged around the hood that is built around the luminaire, further light output can be gained.
39. Keep the luminaires in good working condition.
40. Use high utilization and maintenance factors in design calculations and instruct users to keep fixtures clean and change lamps on a timely basis.
41. Arrange electrical system to accommodate relocatable luminaires which can be removed to suit changing furniture layouts.
42. Use multi-level ballasts to permit varying the lumen output for fixtures by adding or removing lamps when tasks are changed in location or requirements.
43. Control overtime work and cleaning periods.

1 P-3, 1-14

Exhibit 8.14 Heating System Checklist

1. Install timers on boilers, fans, pumps, etc., where "unoccupied" condition permits shutdown.
2. Use electric ignitions in place of gas pilots for gas burners.
3. Extract waste heat from boiler flue gas by various methods such as extended surface coils, heat pipes, flue gas condensate, heat exchanger (reclamation of latent heat in flue gas), etc.
4. Retain coal burning facilities, coal storage rooms, stokers, etc., for primary or secondary fuel use.
5. Use fuel such as bark or sawdust in areas where such is a dependable source of fuel.
6. Consider the use of thermal storage in combination with heat pumps and a hydronic loop so excess heat during the day can be captured and stored for use at night.
7. Replace old inefficient burners with new efficient ones.
8. Install heat pumps (both water/air and air/air) to maximize use of continuing low-grade heat sources.
9. Preheat combustion air to increase boiler efficiency. Manufacturer's recommendations to be followed.
10. Reduce blowdown losses by installing automatic blowdown controls and heat recovery systems.
11. Replace existing boilers with modular boilers.
12. Replace boilers when necessary with new boilers matched to current needs.
13. Insulate existing underground heating lines where piping is in good condition.
14. Convert to a low pressure system to improve the heating system's annual operating efficiency.
15. Install a boiler stack economizer to recycle exhaust heat.
16. Preheat oil to increase efficiency.
17. Add controls capable of providing 100% shut-down of air and water to unoccupied space.
18. Install turbulators in boiler tubes to increase the heat transfer from hot gases to the water side.
19. Install automated damper controls to provide positive draft shut-off when the boiler is not operating.
20. Isolate off-line boilers during light heating loads.
21. Recalibrate existing stack temperature gauge or install new one.
22. Connect space heating hot water pumps to time clocks to operate when the boiler is on line.
23. Install thermostats for control of all heating equipment.
24. Inspect insulation of all mains, risers and branches, economizers, and condensate receiver tanks.
25. Install an automatic night thermostat to control steam pressure during night hours.
26. Inspect boiler door gaskets for tight seal.
27. Install automatic steam control valves on radiators to reduce the need for opening windows in overheated rooms.
28. Inspect nozzles or cup of oil-fired units on a regular basis. Clean as necessary.
29. Heat transfer surfaces of radiators, convectors, baseboard and finned-tube must be kept clean.
30. Keep heat transfer surfaces of all electric heating units clean and unobstructed.
31. Ventilate hydronic units to enable hot water to circulate freely throughout the system.
32. Eliminate hot standby boilers.
33. Operate minimum heating water pumps when necessary
34. Examine operating procedures when more than one boiler is involved for excessive heating loss.
35. Check flue gas analysis on a periodic basis to make sure burner is adjusted to achieve proper stack temperature.
36. Adjust air/fuel ratios of firing equipment to specifications.

Exhibit 8.14

(Continued)

37. Inspect boilers for scale deposits, accumulation of sediment on water side surfaces.
38. Inspect linkages periodically for tightness. Adjust when slippage or jerky movements observed.
39. Keep a daily log of pressure, temperature, and other data obtained from instruments.
40. Inspect fireside of the furnace and tubes for deposits of soot, flyash, and slag.
41. Observe the fire for faulty solenoid valve when the unit shuts down.
42. Check automatic temperature control system and related control valves to ensure proper regulation of system.
43. Inspect zone shut-off valves to make sure they can shut off steam to unoccupied areas.
44. Check accuracy of recording pressure gauges and thermometers.
45. Inspect electric heating elements, controls, and fans on a periodic basis to ensure proper functioning.
46. Check reflectors on infrared heaters for proper beam direction and cleanliness.
47. Listen to steam traps to determine if they are opening and closing when required.
48. Clean mineral or corrosion buildup on gas burners.
49. Inspect all boiler insulation, refractory, brickwork, and boiler casing for hot spots and air leaks.
50. Check burner firing period for sign of faulty controls.
51. Inspect oil heaters to ensure that oil temperatures are being maintained according to recommendations.
52. Inspect oil line strainers. Replace if dirty.
53. Readjust damper control to maintain proper draft under both low and high fire.
54. Turn off the boiler natural gas standing pilot during the summer months when boiler is shut down.
55. Determine if all installed heating is necessary.
56. Calibration of all instruments should be checked annually and corrected if inaccurate.
57. Inspect coal-fired stokers, grates, and controls for efficient operation.
58. Check and repair oil leaks at pump glands, valves, or relief valves.
59. Measure with the gas meter the fuel consumption of the boiler on manual vs. automatic firing.
60. Adjust the boiler for low fire during spring, summer, and fall.
61. Operate one boiler during most of the winter heating season and during entire season if possible.
62. Turn off heating system 30 minutes before the building will be unoccupied.
63. Reduce the space heating hot water temperature to heating needs.
64. Shut off or remove heating units from vestibules, lobbies, and corridors.
65. Heat store rooms only if necessary for protection of stored contents.
66. Do not heat parking garages.
67. Lower steam pressure to the standard minimum.
68. Revise fan drive or trim pump impeller for required flow with no throttling in existing systems where throttling is necessary.
69. Install door grill in inside furnace room door to provide adequate combustion.
70. To reduce steam piping heat losses, valve off steam headers in the boiler room to individual air handling units when they are off.
71. Hire a temperature control expert to check and adjust all system controls and recommend modifications.
72. Reinsulate some of the steam piping, especially near the air handling units.
73. Change fans and pumps from steam to electric motor devices to permit reduction of steam pressure in mild weather.

1P-3, 1-16

Exhibit 8.15 Cooling System Checklist

1. Operate only necessary chilled water pumps and cooling tower fans.
2. Consult with manufacturer to determine if cooling equipment can be shut down when outside temperatures are below certain levels.
3. Eliminate cooling building during unoccupancy.
4. Insulate existing underground chilled water piping if there is an excessive heat loss indicated.
5. For cooling only (or primarily cooling) systems, relocate the fan motor outside of the conditioned air stream.
6. Select high efficiency pumps that match load. Do not oversize.
7. Use modular pumps to give varying flows that can match varying loads.
8. Replace single-speed fan motors with multi-speed motors.
9. For existing cases, such as conference rooms, where air-cooled packaged air conditioners may be installed and 100% outside air remains unnecessary, route exhaust air from space to supply cooler-than-outside air to the condenser.
10. To enhance the possibility of using waste heat from other systems, design air handling systems to circulate sufficient air to enable cooling loads to be met by 60°F air supply temperature.
11. Select chillers that can operate over a wide range of condensing temperatures and then consider the following:
    - a. Use a double bundle or cascade arrangment of condensers.
    - b. When waste heat cannot be used directly or stored, operate the chiller at the lowest possible condensing temperature compatible with equipment limitations and with ambient outdoor conditions.
12. Consider operating chillers in series to increase efficiency on standard duty and cascade heat recovery systems.
13. Consider chilled water storage systems to allow chillers to operate at night when condensing temperatures are lowest and to allow smaller sizes of equipment.
14. Add condensers (additional heat exchanger) to chillers for lower fouling factor and lower condensing temperatures.
15. Consider the use of double bundle evaporators so that chillers can be used as heat pumps to upgrade stored heat for use in unoccupied periods.
16. Install automatic valves on cooling tower bleed to avoid excessive bleed.
17. Use adiabatic saturation (evaporative cooling) to reduce temperature of hot dry air to extend the period of time when "free cooling" can be used.
18. Use outdoor air for sensible cooling whenever conditions permit and when recaptured heat cannot be stored.
19. For 100% outside air systems (laboratories, etc.), consider pre-cooling coils using the cooling tower as the cooling source either alone or in conjunction with the refrigeration plant.
20. Design chilled water systems to operate with as high a supply temperature as possible.
21. Consider atmospheric or induced draft type cooling towers for least energy use.

1 P-3, 1-17

Exhibit 8.15
(Continued)

22. In lieu of exhausting air directly to atmosphere on outside air cycle, route air to cool such spaces as occupied storerooms.
23. Increase the number of cooling towers so that:
    a. Fan-off atmospheric cooling may be obtained.
    b. Low condensing water temperature may be obtained.
24. In the summer when the outdoor air temperature at night is lower than indoor temperature, use full outdoor air ventilation to remove excess heat and precool the structure.
25. Replace inefficient air conditioners.
26. Calibration of all instruments should be checked annually and corrected if inaccurate.
27. Check and repair oil leaks at pump glands, valves or relief valves.
28. Turn off cooling system 30 minutes before the building will be unoccupied.
29. Relocate the fan motor outside of the conditioned air stream for cooling systems.

Exhibit 8.16 Heating, Ventilating and Air Conditioning System Checklist

1. To reduce fan horsepower, do the following:
    a. Design duct systems for lowest possible pressure loss.
    b. Use high efficiency fans.
    c. Use low pressure loss filters.
2. Replace single speed fan motors with multi-speed motors.
3. In principle, select the air handling system which operates at the lowest possible air velocity and static pressure.
4. Reduce or eliminate air leakage from duct work and from around coils.
5. Provide outdoor air directly to the perimeter of exhaust hoods in kitchens, laboratories, etc.
6. Transfer air from "clean" areas to more contaminated areas (toilet rooms, heavy smoking areas) rather than supply fresh air to all areas regardless of function.
7. Reduce the energy required to heat or cool ventilation air from outdoor conditions to interior design conditions by doing the following: Reduce indoor air temperature setting in winter and increase in summer except with existing reheat systems.
8. Consider omitting heating coils in units serving interior spaces.
9. Exchange heat between outdoor air, intake, and exhaust air by using heat pipes, thermal wheels, run-around systems, etc.
10. Consider the use of spot heating and/or cooling in spaces having large volume and/or low occupancy.
11. Design HVAC system so it does not heat and cool air simultaneously.
12. Do not use terminal reheat system.
13. Use reheat for humidity control only where warranted by an industrial type of process.
14. Consider converting terminal reheat and/or dual duct systems to variable air volume systems of the type that are low in maintenance and require no external controls.

1 P-3, 1-18

Exhibit 8.16

(Continued)

15. Construct enclosures around rooftop units to reduce radiation and wind losses from exposed ducts.
16. Inspect thermostat locations. Relocate if they currently are positioned near areas subject to outside drafts.
17. Balance mechanical ventilation and provide building static pressure control so that supply air equals or exceeds exhaust air quantity.
18. Replace outside air dampers with low leakage type.
19. Operate exhaust fans only when needed. Install separate time clocks to regulate cycles.
20. Install individual time clocks for each fan unit.
21. Install a central control panel for all building systems.
22. Consider heat recovery or exchange between make-up and exhaust air.
23. Add automatic controls to shut down the ventilation system whenever the building is closed for an extended period of time.
24. Add a warm-up cycle to air handling units with outdoor air intake.
25. Modify duct systems and hoods to introduce unheated outdoor or return air directly to the exhaust hood.
26. Insulate all ductwork carrying conditioned air through unoccupied spaces.
27. Reduce fan power input equipment by reducing air volume.
28. Install baffles to prevent wind from blowing directly into outdoor air intakes.
29. Adjust oversized exhaust hoods so no more air than necessary is exhausted.
30. Use exhaust hoods in necessary rooms only while operations are underway.
31. Cover all window and through-the-wall cooling units when not in use.
32. Establish a ventilation operation schedule so that the exhaust system operates only when it is needed.
33. Inspect all outdoor air dampers to make sure they are airtight. Inspect position indicators for accuracy (dampers).
34. Reduce outdoor air to the minimum required to balance the exhaust requirements and maintain positive pressure.
35. Adjust the automatic day-night settings to operate ventilation units fewer hours during the day cycle.
36. Reduce mechanical ventilation in proportion to amount of building ventilation.
37. Operate the ventilation system only when the office is occupied.
38. Clean debris from unit ventilators to permit more efficient operation.
39. Clean the filters more often to increase the overall efficiency of the air handling units.
40. Use full outdoor air ventilation to remove excess heat and pre-cool the structure to reduce air condition load in the summer.
41. Increase mixed air temperature during summer to minimize the air conditioning and reheating requirements.
42. Change all fresh air limit control settings to make them consistent.
43. Close outdoor air dampers tightly during unoccupied periods.
44. Post instructions on each operable window to keep closed while the building is being heated or cooled.

1P-3, 1-19

Exhibit 8.17 Process Energy Checklist

Process Steam

1. Check steam system for leaks and condition of steam traps and insulation.
2. If condensate is discharged to drain, can the heat be recovered?
3. Can condensate be returned to boiler if there is no possibility that it can become contaminated?
4. Can boiler be cycled by time clock controls to match hours of production?
5. Clean coils and heat exchangers on regular basis to maintain efficiency.
6. Does boiler have a water treatment program for scale, corrosion, and solids?
7. If boiler has continuous blowdown, can the blowdown be used to heat make-up water?
8. Can an economizer be installed on boiler?
9. If small process load is served by heating boiler, can a small steam generator be used during non-heating season?
10. Can use of steam for heat in a process be replaced by a more efficient source?
11. Is heat necessary? Example: Use of a cold cleaning process in place of a hot cleaning process.

Compressed Air

1. Check lines and fittings for leaks.
2. Can compressed air be replaced with another more efficient energy source? Example: Use small electric conveyor to remove parts instead of compressed air.
3. Can air compressor be placed on time clock?
4. Can heat from compressor be used for space heating?
5. Can compressor be staged to come on with load?
6. Use outside air for compressor inlet to reduce energy by compressing cooler air.

General

1. Are motors sized correctly?
2. Are ventilation fans controlled?
3. Can waste heat be recovered from process to pre-heat or for space heating?
4. Is equipment being used at efficient load levels?
5. Install turbulators in radiant heat treat furnace.
6. Reduce ventilation systems to minimum by close capture hoops.
7. Turn equipment off during breaks and lunch periods. Be careful not to turn them all back on at once and create a costly electrical demand peak.
8. Consider energy usage and cost on new purchases or processes.
9. Does the plant have alternate fuel sources for process?
10. Can waste oils be recovered for burning in boiler?
11. Can waste heat from incinerators be recovered?

POST-CHECK

WAYS AND MEANS OF REDUCING HOME AND SMALL BUILDING ENERGY USE

Take a walk around the outside of your house and throughout the inside of your home. Make a complete list of area you believe could be improved to save energy. In addition, list strateg(ies) you could use to reduce energy consumption. Record all observations. Keep this list as you work through the other modules. Show your instructor to give approval of your task.

____
Instructor's Approval

MODULE TEN

PRINCIPLES AND PRACTICES OF HEAT LOSS AND GAIN

Prepared

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PRINCIPLES AND PRACTICES OF HEAT LOSS AND GAIN

The understanding required by the Industrial Arts teacher to adequately teach energy conservation in homes and small buildings involves heat loss and gain. The needed knowledge comes from basic thermodynamics, as applied to materials, structures, and practices related to heat loss and gain.

TERMINAL PERFORMANCE OBJECTIVE

Upon completion of this module, you will be able to: identify, define, and apply concepts, principles, and formulas associated with heat transfer, measurement units, and other necessary factors used for the determination of heat loss and heat gain for residential structures and small buildings.

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1.	Heat and Mechanisms of Heat Transfer	____	____
IP-2.	Heat Loss/Gain Equations	____	____
IP-3.	Seasonal Fuel Use and Costs	____	____

PRE-CHECK

PRINCIPLES AND PRACTICES OF HEAT LOSS AND GAIN

Directions: Place a "T" if the statement is true, or an "F" if the statement is false.

1P-1. Heat and Mechanisms of Heat Transfer

_____1. A BTU is a measure of heat energy quantity.

_____2. Conduction heat flow is caused by electro-magnetic transfer.

_____3. Convection heat flow takes place through solids.

_____4. Radiation heat flow is caused by warm air rising and cold air sinking.

_____5. Heat energy coming from a fireplace is an example of convection heat flow.

_____6. Infiltration is created by temperature differences.

_____7. The symbol Q means heat loss.

_____8. Qcv means convective heat loss.

_____9. Qi means heat transfer by infiltration.

____10. Qc means conductive heat loss.

1P-2. Heat Loss/Gain Equations

_____1. K value is thermal conductivity.

_____2. C value is thermal conductivity through one ft. of homogeneous material one inch thick, in an hour, for each degree fahrenheit of temperature difference.

_____3. U value is thermal resistivity or the reciprocal of thermal conductance.

_____4. R value is the thermal resistivity of a material to heat flow.

_____5. U value is the coefficient of transmission or the reciprocal of the total thermal resistance of a material to heat flow.

_____6. The crack method and air-exchange method are two common methods to determine Sol-Air-temperature.

PRE-CHECK (Continued)

PRINCIPLES AND PRACTICES OF HEAT LOSS AND GAIN

_____7. Conduction heat transfer is calculated using the equation UA (ΔT).

_____8. Infiltration is calculated using the equation .018 (Qc) (ΔT).

_____9. U value is calculated by adding all R value and dividing the total resistance by a factor of 1.

____10. The equation for determining the cool load of a building is VA (ETD).

1P-3. Seasonal Fuel Use and Costs

_____1. The equation $\frac{24\ hd\ (ti-ta)}{ti-to}$ can be used to determine seasonal heat loss.

_____2. T refers to a difference in temperature between two surfaces.

_____3. The equation to determine seasonal fuel use is $\frac{Q \times D \times 24}{\Delta T}$.

_____4. The equation Qs $\frac{CD \times CF}{Y \times V}$ can be used to determine seasonal heat loss.

_____5. ti means inside temperature.

_____6. To is used to determine ΔT.

_____7. H means hourly heat loss from the building for the design conditions.

_____8. h means seasonal heat loss in BTU.

_____9. Υ means full load efficiency of a heating system.

PRE-CHECK KEY

PRINCIPLES AND PRACTICES OF HEAT LOSS AND GAIN

IP-1. Heat and Mechanisms of Heat Transfer

1. True
2. False
3. False
4. False
5. False
6. True
7. True
8. False
9. True
10. True

IP-2. Heat Loss/Gain Equations

1. True
2. False
3. False
4. False
5. True
6. False
7. True
8. False
9. True
10. True

IP-3. Seasonal Fuel Use and Costs

1. True
2. True
3. True
4. False
5. True
6. True
7. False
8. False
9. True

PRINCIPLES AND PRACTICES OF HEAT LOSS AND GAIN

IP-1. Heat and Mechanisms of Heat Transfer

OBJECTIVES

This instructional package will help you to identify the principles of heat transfer in the home and small buildings. At the completion of this instructional package, you will be able to:

A. Define heat.

B. Distinguish and define four transfer mechanisms.

C. Define other characteristics of heat as they relate to the determination of heat loss in the house.

RESOURCES

The following resource is provided for you to use in attaining the objectives:

Information Sheet IP-1, 1-1 through 1-4 - "Heat and Mechanisms of Heat Transfer."

ACTIVITY

A. Review Instructional Package resources listed below:

1. "Heat and Mechanisms of Heat Transfer"

B. Determine heat transfer characteristics through an understanding of heat principles and heat flow mechanisms.

1. Define in writing the following heat transfer concepts.

_________1. Heat

_________2. British thermal unit

_________3. Conduction

_________4. Convection

_________5 Radiation

_________6. Infiltration

_________7. Home heat gain

_________8. Home heat loss

_________9. Temperature Difference

2. Match heat transfer equations with related statements.

_____1. T
_____2. q
_____3. qc
_____4. Ti
_____5. Qcr
_____6. To
_____7. qi

a. Outside temperature
b. Resistance to heat transfer
c. Total heat loss
d. Inside temperature
e. Heat flow by infiltration
f. Temperature difference
g. Heat flow by radiation
h. Coefficient of heat transfer
i. Heat flow by conduction

"HEAT AND MECHANISMS OF HEAT TRANSFER"

To determine the energy efficiency of a home, through the determination of energy consumption, familiarity with the fundamentals of heat and heat transfer is required. This instructional package will, therefore, be devoted to the principles of heat transfer, their relation to thermodynamics, and their application to heat loss calculations.

Energy can exist in many forms and in fact a system can possess several forms of energy. You have probably heard of the terms nuclear, electrical, chemical, thermal kinetic, potential, and so forth; the more or less pure forms of energy. In a colloquial sense we talk of solar energy, wind energy, goethermal energy, etc.

Whenever a temperature difference (ΔT) exists, energy may be transferred from the region of high temperature to the region of lower temperature. According to thermo-dynamic concepts, the energy that is transferred as a result of a temperature difference is called heat, Q. Heat results from the vibration of molecules of any substance. The more rapidly the molecules vibrate, the higher the temperature. Therefore, heat can be defined as a form of energy. Temperature is intensity, not the quantity of heat.

Energy in transition always proceeds from a state of higher energy to a state of lower energy. In the study of heat transfer this means that a substance at temperature T_1 in proximity to another substance at a lower temperature T_2 will transfer energy to the substance at lower temperature. The effect will be to decrease T_1 and increase T_2 until the system comprised of both substances is in thermal equilbrium. For example, a building heated lower than 72°F will lose heat to the outside when the temperature there is lower than 72 F. In winter, heat flows from the warm interior of a house to the cooler exterior; this is referred to as "heat loss." In summer, heat flows from the warmer exterior to the cooler interior of a house; this is called "heat gain."

In calculating the heat loss of a building, the unit of heat measure known as the British Thermal Unit (BTU) is used. The BTU is the unit of measure for the quantity of heat that seeks an equilibrium of temperature between two temperature differences. The BTU is the amount of energy required to raise the temperature of one pound of water one degree F. Following are BTU fuel equivalents:

1 Wooden Kitchen Stick Match = 1 BTU
1 Kilowatt (KW) Hour Electricity = 3413 BTU
1 Cubic Foot Natural Gas = 1031 BTU
1 Ton High Volatile Bituminous Coal = 26,000,000 BTU
1 Gallon Fuel Oil = 140,000 BTU

Why Heat a Home?

With the above in mind, think for a moment why houses are heated. To keep warm? Not really. After all we normally heat our homes to about 65^{o} - 68^{o} F; our normal body temperature is 98.6^{o}F, so we are actually 33^{o}F or so warmer than our homes. Heating our house to 68^{o}F is certainly not going to "warm" us sine we know heat flows from "warm" T_1 to "cool" T_2. This should give you the hint. You see that really we heat our surroundings (unless the ambient air is much warmer than we are).

Human beings are "homotherms" which means there is an internal biological mechanism that attempts to keep our bodies at approximately 98^{o}F. We have in our bodies what is probably the most precise thermostat in existence. The chemical energy in the food we eat is converted to different forms, including thermal. There is a very narrow range of temperatures in which the body can function properly. More than about 8^{o}F difference above or below normal for any appreciable period of time usually results in permanent physiological damage, even death.

So the reason we heat our homes is to regulate within acceptable limits the loss of body heat to the surroundings.

1P-1, 1-3

HEAT TRANSFER MECHANISMS OF HOME HEATINGS

We now realize that the real goal in home heating for comfort is to protect the body from excessive heat loss to the surroundings. To heat the house, heat is transferred by one or a combination of mechanisms; conduction, convection and radiation.

Heat flow by conduction (Qc) is a process in which heat is transmitted from one part of a body to another part of the same body without any relative displayment of the parts of the body by means molecular vibration. The faster moving molecules in the body creating the most heat give off energy to the adjoining slower moving molecule which in turn move faster. This process will continue until all molecules in the body or adjoining bodies are vibrating at the same rate which implies that they will have the same temperature. An example of this would be heat applied to a skillet sitting on a hot stove.

You might suspect then that if the molecules are more "tightly packed" within a material they will come in contact more frequently and therefore heat transfer by conduction will be greater then for materials whose molecules are "loosely packed". This is in fact the case. So in general we can say that materials of high density have high thermal conductivity.

Based on the above discussion we would guess that the best materials for home insulation are those with low density. In general, low density means a large amount of trapped gas within a material. Generally this gas is air. The conclusion you should draw is that air is a good insulator.

Conduction is measured is BTU/HR.

Heat flow by convection is totally unlike conduction. In this case the molecules of a fluid (either liquid or gas) pick up heat energy from a warm surface, carry it with them over a great distance (relative to their own size), and drop the energy at at cooler surface. If the cool molecules return for a second trip, we have a convection loop.

To understand heat by convection, we first understand why fluid molecules would want to convect in the first place. Warmer fluid molecules, having more energy, require more "personal space". Upon warming, therefor fluids expand and become less dense. Like hot-air balloons or logs in the water, they rise. On the other hand, cooling fluids become more dense and sink. "Hot air rises, cold air falls". Convection is that simple.

IP-1, 1-4

Convection would apply to warm air rising in a convection furnace system, or movement of air over a hot surface such as a radiator, or heating element. Convection applications found in housing may be the air flow concept used in the "envelope" or double-shell house, the thermosiph n water flow concept of a thermosiphon water heater and "convective-loop" created within natural convection collectors.

Heat flow by infiltration (Qi) is a special case of convection. It is the physical replacement of warm inside air by cold outside air (or the reverse in the summer) through cracks and openings in and around the home. Infiltration losses increase with winds forcing air into the house. Since heat must be added to the incoming air continually in order to maintain the house temperature, infiltration amounts to a rate of heat loss. Infiltration is qualified in either cubic feet of air per minute (cfm) or total house volume air exchanges per hour.

Heat flow by radiation is the movement of heat away from an object by means of electro-magnetic waves or infrared rays. This process does not involve any molecule other than the substance radiating the heat. It can occur through a vacuum and is the mechanism by which the heat of the sun is transferred to earth. If you sit in front of a hot stove or fire you will feel the radiated heat. Radiation heat flow is also the mechanism which makes you feel cold when sitting next to a window on a cold winter day. Since you are warmer than the window your body is radiating heat to the cold body (window).

FEEDBACK

Objective A Check:

1. Form of energy that is transferred as a result of a temperature difference.
2. Measure of heat energy quantity (BTU required to raise temperature of one pound of water one degree F).
3. Heat flow through solid materials.
4. Heat flow caused by warm air rising and cooler air sinking.
5. Heat transfer from one space to another by means of electromagnetic energy.
6. Physical replacement of warm inside air by cold outside air through cracks and other openings throughout the home.
7. Heat transferred from outside of house to inside of house during summer.
8. Heat transferred from house to outside during winter.
9. Inside heating design temperature (65-70 F) minus outside winter design temperature for given area.

Objective B Check:

1. f
2. c
3. i
4. d
5. g
6. a
7. e

IP-2. Heat Loss/Gain Equations

OBJECTIVES

This instructional package will help you to calculate heat flow by using equations that determine residential and small building heat loss. At the completion of this instructional package, you will be able to:

A. Apply, identify, and describe which formulas are used for determining heat transfer in buildings.

B. Write definitions for terms used for determining heat transfer in buildings.

RESOURCES

The following resource is provided for you to use in attaining the above objectives.

Information Sheet IP-2A, 1-8. "Understanding Heat Losses and Gains in Buildings."

Information Sheet IP-2B, 1-14 "Special Applications for Estimating Cool Loads in Buildings."

These two Information Sheets are found in USDOE publication Providing for Energy Efficiency in Homes and Small Buildings, Part II; Determining Amount of Energy Lost or Gained in a Building, American Association for Vocational Instructional Materials, Technical Information Center, P.O. Box 62, Oak Ridge, Tennessee, 1980.

ACTIVITY

A. Review the instructional package resource (IP-2A) "Understanding Heat Losses and Gains in Buildings" and (IP-2B) "Special Applications for Estimating Cooling Loads in Buildings."

B. Identify formulas used to determine heat transfer in buildings.

Explain in writing the following concepts:

__________1. K Value

__________2. C Value

__________3. r Value

__________4. R Value

__________5. U Value

__________6. Rt

__________7. "Crack Method

__________8. "Air Exchange Method"

__________9. Sol-Air temperature

__________10. ETD

__________11. te

Match heat transfer equations with related statements.

__________1. Conduction heat transfer
__________2. Total thermal resistance
__________3. Area
__________4. Infiltration sensible cooling load
__________5. Volume
__________6. Infiltration
__________7. U Value
__________8. Conduction & Radiation heat transferred
__________9. Cooling load
__________10. Air Exchange

a. LxW
b. .018 (Qi) (Δ T)
c. UA (T)
d. UA (ETD)
e. R +R2 + R3 +...
f. LxWxH
g. 1/R
h. qs $\frac{CD \times Cf}{x \; v}$
i. UA (te-ti)
j. (Qis)
k. qi

Distinguish formulas by selecting the forumla(s) that does not "fit" with the statement.

_____1. Conduction-Heat Transfer

A. $\frac{KA}{L}$ (T)

B. CA (T)

C. 0.018 (Qv) (T)

D. $\frac{A}{R}$ (T)

ACTIVITY (Continued)

_____2. Infiltration-heat transfer

A. ti-to
B. UA (ti-to)
C. $\frac{q \times DD \times 24}{t}$
D. .018 (Qi) (ti-to)

Understanding Heat Losses and Gains in Buildings

Heat transfer through building sections is computed by the use of formulas. Once you understand the formulas, it is a simple matter to substitute the values and arrive at heat losses or gains.

From your study of this section you will be able to explain which formulas are used for determining heat transfer in buildings and the terms used.

They are discussed under the following headings:

1. Conduction Heat Flow Through Homogeneous Materials.
2. Conduction Heat Flow Through Composite Walls.
3. Infiltration Heat Losses or Gains.
4. Ventilation Heat Losses or Gains.
5. Radiation Heat Losses or Gains.
6. Energy Losses and Gains from Equipment Operation.

1. CONDUCTION HEAT FLOW THROUGH HOMOGENEOUS MATERIALS

The fundamental relationship defining conduction heat flow through a homogeneous solid is the Fourier equation:

$$\underset{\text{(Btu/hr)}}{\text{Heat Transfer}} = \frac{\text{Conductivity of material (k)} \times \text{surface area (sq. in.)}}{\text{Thickness in inches}} \times \begin{array}{l}\text{Temperature Difference} \\ \text{between the sides of the} \\ \text{solids } (t_2 - t_1) \text{ in °F}\end{array}$$

or

$$q_c = \frac{kA}{L}(t_2 - t_1)$$

Where

q_c = Heat flow by conduction (Btu/hour).

k = Thermal conductivity of the material, Btu/hr x ft^2 x °F x In.

L = Thickness of the solid in the direction of heat flow in inches.

$(t_2 - t_1) = \Delta T$ = Temperature difference between the two surfaces of the solid (°F).

A = Area of the solid perpendicular to the direction of heat flow.

The terms in equation 1 are illustrated in Figure 1.

It is important that equation 1 and its implications be understood. Notice that the heat transfer by conduction through the material will be small if:

- A material with a small conductivity (k) is used.
- The material thickness (L) is large.
- The temperature difference $(t_2 - t_1)$ between the two surfaces is kept small.
- The area (A) of the wall is kept small.

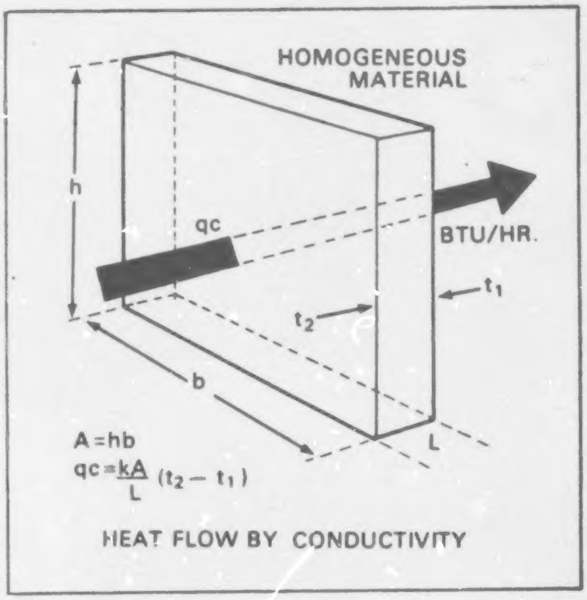

FIGURE 1 Conduction heat flow definition sketch.

IP-2A,1-2

Conduction heat losses in a building can be minimized by decreasing the building size, by selecting thick materials with low thermal conductivities, and by reducing the temperature difference between inside and outside air.

The thermal conductivity (k) of a material is a physical property which is obtained experimentally in the laboratory. Note that the conductivity is based on a material thickness of unity, or 1 inch. The conductivities of selected building materials are given in Table III.

Often, the thermal conductivity (C) of a material is given for a specified thickness rather than for a unit thickness. Typical cases are 8-inch concrete masonry blocks, or dressed timber boards. When the thermal conductivity is given for a specified thickness, it is called the thermal conductance (C). Typical values of thermal conductance are also given in Table IV.

When thermal conductances of materials are used, the conduction heat transfer equation must be modified since the material thickness is already incorporated into the conductance value. Thus

$$\underset{\text{(Btu/hr)}}{\text{Heat Transfer}} = \underset{\text{(C)}}{\text{Thermal Conductance}} \times \underset{\text{(A)}}{\text{Area}} \times \underset{(t_2 - t_1)}{\text{Temperature Difference}}$$

$$q_c = CA\ (t_2 - t_1)\ .\ .\ .\ .\ \text{(Equation 2)}$$

where C = thermal conductance, Btu/hr x ft^2 x Δt°F.

Another common way to describe a material's ability to conduct heat is its thermal resistivity (r) and thermal resistance (R). The resistivity is the reciprocal of the conductivity, whereas, the resistance is the reciprocal of the conductance. That is, the resistivity is the material's resistance to heat flow per unit thickness and the resistance is the material's resistance to heat flow for a specified thickness. Typical resistances are given for some insulation materials in Table I.

$$\underset{\text{(r)}}{\text{Thermal Resistivity}} = \frac{1}{\text{Conductivity (k)}}$$

$$R = \frac{1}{\text{Conductance (C)}} = \frac{\text{Thickness of material}}{\text{Conductivity (k)}}$$

$$r = 1/k \text{ and } R = 1/C = L/k\ .\ .\ \text{(Equation 3)}$$

The conduction heat flow equation for a single material can now be expressed in terms of thermal resistivity and resistance by:

$$\underset{\text{(Btu-hr) }(q_c)}{\text{Conduction Heat Flow}} = \frac{1}{\text{Resistance (R)}} \times \frac{\text{Area (A) (ft}^2)}{\text{Thickness (L) (in)}} \times \underset{(t_2 - t_1)}{\text{Temperature Difference}}$$

$$q_c = \frac{1}{r}\frac{A}{L}\ (t_2 - t_1)\text{, and}\ .\ .\ .\ \text{(Equation 4)}$$

$$q_c = \frac{1}{R} A\ (t_2 - t_1)\ .\ .\ .\ .\ .\ \text{(Equation 5)}$$

EXAMPLE NO. 1

To illustrate the use of the conduction equation, suppose a 4' x 8' sheet of 1/2-inch thick plywood has surface temperatures of 100°F and 70°F. Evaluate the heat conducted through the panel.

The thermal properties of the plywood are:

k = 0.80
C = 1.60
r = 1.25
R = 0.625

The heat conducted in Btu/hour may be calculated by either equation (1), (2), (4) or (5):

$$q_c = \frac{kA}{L} (\Delta t) = \frac{0.8 (4x8)\ (100-70)}{0.5} = 1536 \text{ Btu/hr}$$

$$q_c = CA\ (\Delta t) = 1.6 (4x8)\ (100-70) = 1536 \text{ Btu/hr}$$

$$q_c = \frac{A}{rL} (\Delta t) = \frac{1}{1.25} \frac{(4x8)}{0.5} (100-70) = 1536 \text{ Btu/hr}$$

$$q_c = \frac{A}{R} (\Delta t) = \frac{4x8}{0.625} (100-70) = 1536 \text{ Btu/hr}$$

2. CONDUCTION HEAT FLOW THROUGH COMPOSITE WALLS

If structural components were made of single homogeneous materials, equations (1), (2), and (4) would be adequate to estimate conduction heat flow. Most wall partitions, however, are composite walls. That is, they are constructed of two or more materials as shown in Figure 2.

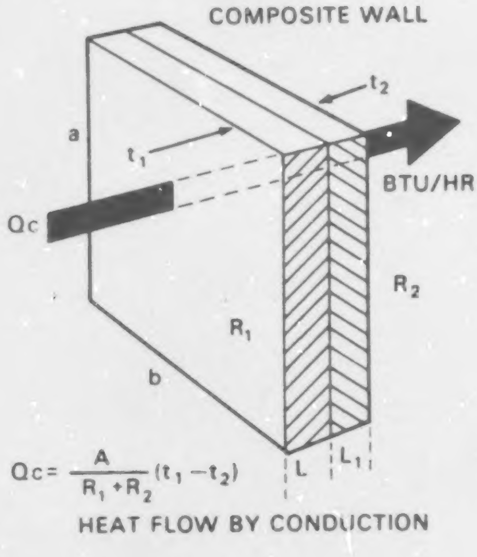

FIGURE 2. Definition sketch for a composite wall.

The procedures for estimating heat flow through a composite wall follow:

The total thermal resistance (R_T) of the composite wall is the sum of the resistance of each component of the wall. In equation form

$$R_T = R_1 + R_2$$

$$R_T = L/k_1 + L/k_2 \quad . . . \text{ (Equation 6)}$$

By placing the total thermal resistance into the conduction equation, the conduction heat transfer through a composite wall is

$$q_c = \frac{1}{R_T} A\ (\Delta t) \quad . . . . \text{ (Equation 7)}$$

Another way to write equation 7 is to let $U = 1/R$; then

$$q_c = UA\ (\Delta t) \quad . . . . . \text{ (Equation 8)}$$

where U = overall heat transmission coefficient, Btu/hr x ft^2 x °F.

When determining the overall thermal resistance of a wall, it is only necessary to add up the resistances of each component in the wall. Fortunately, the total thermal resistance and overall thermal transmission coefficients are tabulated for many partition constructions.*

---

*From Table V.

1P-2A, 1-4

The following example will illustrate how to evaluate overall transfer coefficients and heat flow through composite walls.

EXAMPLE NO. 2

Evaluate the conduction heat transferred through a 8' x 10' wall section composed of 3/4-inch wood siding, 3 1/2-inches fiberglass insulation and 1/2-inch gypsum board (Figure 3).

Outside temperature (t_o) 10°F.
Inside temperature (t_i) 68°F.

	R-Values *
Outside film	0.17
Wood siding	0.81
Sheathing	1.32
Insulation	11.
Gypsum board	0.45
Inside film	.68
R_T =	14.43

*From Table V.

NOTE: There is a small amount of resistance due to the air film on both the outside and inside surface of materials.

$q_c = UA\,(\Delta t)$

$R_T = R_o + R_{sh} + R_{wood} + R_{insul} + R_{gb} + R_i = 0.17 + 1.32 + 0.81 + 11.0 + 0.45 + 0.68 = 14.43$

Thus $U = 1/R_T = 1.14.43 - 0.069$

and $q_c = 0.069\ (8 \times 10)\ (68-10) =$ 321 Btu/hr.

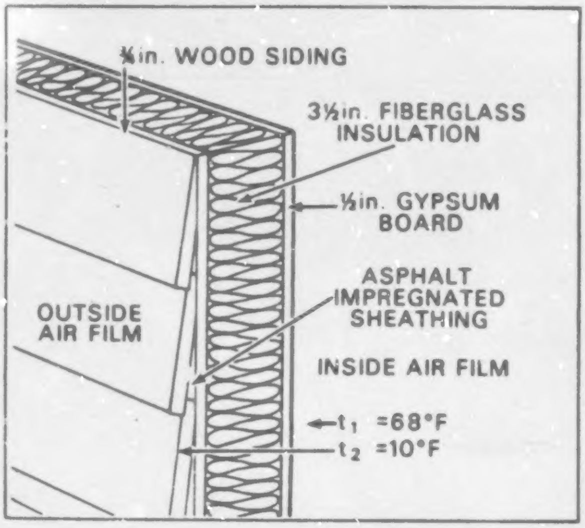

FIGURE 3 Sketch of wall section for conduction heat flow through a composite wall.

Using Table V, the overall heat transfer coefficient is U-0.081. The discrepancy between U calculated (.069) and U tabulated (0.081) is that the tabulated values account for the difference in thermal resistance at the studs and between the studs. The tabulated U-Value is the weighted average of the U-Values at and between the studs.

To illustrate the value of insulation, consider the same composite wall, but remove the 3 1/2 inches of insulation. Now the insulation is replaced by a vertical air space which has a resistance of 1.01 and

$$R_T = R_o + R_{sh} + R_{wood} + R_{air} + R_i$$

$$= 0.17 + 1.32 + 0.81 + 1.01 + 0.45 + 0.68 = 4.44$$

and $U = 1/R = 1/4.44 = 0.23$

and $q_c = UA\,(\Delta t) = 0.23\ (8 \times 10)\ (68-10) = 1044$ Btu/hr

IP-2A, 1-5

Note that by removing the insulation, the heat flow by conduction through the wall increased from 321 to 1044 Btu/hr. The heat loss increased by a factor of 2.25.

EXAMPLE NO. 3

To illustrate the influence of indoor temperature upon heat loss from a building, consider again the insulated wall section with U - 0.069. Compare the heat flow through the wall for an outdoor temperature of 10°F and inside temperatures of both 60°F and 72°F.

At 60°F, $q_c = UA\,(\Delta t) = 0.069\ (80)\ (60-10) = 276$ Btu/hr.

AT 72°F, $q_c = UA\,(\Delta t) = 0.069\ (80)\ (72-10) = 342$ Btu/hr.

By increasing the indoor temperature from 60° to 72°F, Δt increased and thus increased the heat loss through the wall by 66 Btu/hr, or by 24%.

3. INFILTRATION HEAT LOSSES OR GAINS

Outside air enters a residence through many unplanned cracks in walls, doors and windows. This air movement is called infiltration. Since infiltration air is seldom at the temperature of the air inside the living area, it must be warmed or cooled. This fact, of course, represents a heat loss by the house during cold weather and a heat gain by the house during warm weather.

In estimating infiltration heat flow, it is necessary to estimate first the volume, or cubic feet, of air which flows into the building. The quantity of air flow is dependent upon many factors, including the number and sizes of cracks in the structural components and the outside wind speed.

There are two basic methods for evaluating the infiltration air volume. One method requires that the crack widths and lengths and the wind speeds be estimated whereupon air flow can be evaluated. Another method is the air exchange method. In this method, tabulated values of the number of air changes occurring per hour are used for typical residential rooms. Typical air exchange values are given in Table VI. Note that an air exchange rate of 1.0 per hour indicates that the air flow into the room per hour equals the volume (length x width x height) of the room.

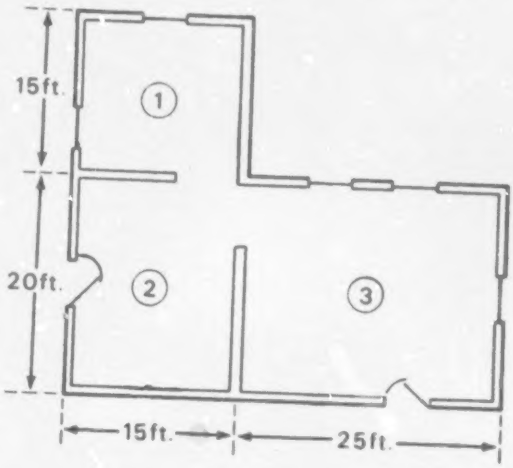

FIGURE 11. Plan view for infiltration volume illustration.

In residential construction the air exchange method is sufficiently accurate for infiltration volume calculations and is much simpler than the crack length and width method. Thus, the air exchange method will be used exclusively in this text.

EXAMPLE NO. 4

To illustrate the air exchange method, estimate the infiltration air volume for the simple house plan show in Figure 11, if the ceiling height is 8 feet and if the windows are not weatherstripped or storm sashed.

The infiltration air volume for each room is estimated by the formula:

Infiltration volume = Q_i = Air exchanges x room volume

For room (1): $Q_i = 1.5\ (15x15x8)$ = 2700 cu. ft/hr

For room (2): $Q_i = 1.0\ (15x20x8)$ = 2400 cu ft/hr

For room (3): $Q_i = 2.0\ (20x25x8)$ = 8000 cu ft/hr

For whole house: $Q_i = 2700 + 2400 + 8000 = 13{,}100$ cu ft/hr

Once the estimate of the volume of infiltration air is obtained, the energy required to heat or cool the air to the temperature of the living area can be calculated by the formula:

$$q_i = (0.018)\ Q_i\ (t_o - t_i)\ .\ .\ .$$

(Equation 10)

Infiltration heat losses can now be illustrated by considering the house in Figure 11 and equation 10. The infiltration heat loss will be calculated when the outside temperature is 10°F and the living area temperature is 65°F.

$$q_i = (0.018)\ Q_i\ (t_o - t_i)$$

$$= 0.018\ (13{,}100)(65-10)$$

$$= 12{,}970 \text{ Btu/hr}$$

Notice that by weatherstripping the windows or adding storm windows, the infiltration heat loss could be reduced by 1/3, or

$$q_i = 2/3\ (12{,}970) = 8{,}650 \text{ Btu/hr}$$

4. VENTILATION HEAT LOSSES OR GAINS

The heat losses and gains due to ventilation air are evaluated in the same manner as infiltration heat losses and gains except the volume of air entering the building is different. That is

$$q_V = 0.018\ (Q_V)\ (\Delta t)\ .\ .\ .$$

(Equation 11)

where q_V = ventilation heat loss or gain, Btu/hr

Q_V = ventilation air volume, cu ft/hr

The ventilation air volume for residences is usually very small as compared to infiltration air volume.

Table VII gives typical ventilation air volumes.

In most single family residences the air exchange obtained by infiltration satisfies the ventilation requirements. If this is the case, the ventilation heat loss or gain is taken care of in the infiltration heat loss calculation. If supplemental ventilation is provided, simply determine the volume of air introduced by the ventilating fans, Q_v, and substitute Q_v into Equation 11.

5. RADIATION HEAT LOSSES OR GAINS

Radiation heat flow is far more important in cooling applications during warm weather than in heating applications during cold weather. Thus, our primary concern will be to estimate solar radiation heat gains during warm weather.

Solar radiation heat gains in residences may be conveniently divided into two categories:

a. Opaque Exterior Surfaces.
b. Windows and Transparent Surfaces.

a. Opaque Exterior Surfaces

When solar radiation strikes a building roof or wall, it increases the temperature of the building surface to a level above the outside temperature. The increased surface temperature thus changes the temperature difference between the inside and outside wall surfaces. Recalling the conduction heat transfer equation, $q_c = UA\ (t_o - t_i)$, an increase in t_o would increase the conduction heat transferred through the wall or roof.

A convenient method for accounting for the solar radiation heat load in a building is to use an equivalent air temperature called the sol-air temperature. Sol-air temperature is the equivalent outdoor air temperature which would yield the same heat transfer through a wall by conduction alone as that transferred due to the conduction heat transferred under the actual outdoor temperature and solar radiation. By using the sol-air temperature, t_e, instead of the actual outdoor temperature, t_o, the combined conduction and radiation heat transferred through opaque surfaces is estimated by equation (12):

$$q_{cr} = UA\ (t_e - t_i)\ .\ .\ \text{(Equation 12)}$$

The design sol-air temperature is dependent upon the solar radiation intensity. Thus, sol-air temperatures are dependent upon the time of the year, geographical location, the orientation of the surface (N, S, E, W), the inclination of the surface (horizontal or vertical), and the color of the wall. The wall color is significant since dark colored walls absorb larger quantities of solar radiation, whereas lightly colored walls tend to reflect a large portion of the incident solar radiation. Typical values of sol-air temperatures are given in Table VIII for a latitude of 40°N on July 21.

Table VIII illustrates vividly the effects of surface color, orientation and inclination upon sol-air temperatures. For example, at solar noon, when outside air temperature equals 90°F, sol-air temperatures of vertical surfaces varied from 96 to 112°F dependent upon orientation. At the same time the dark colored vertical surfaces experienced sol-air temperatures between 103 and 134°F. Comparison of sol-air temperatures for horizontal surfaces at solar noon indicates a difference of 172-127°F, or 45°F, between dark and light colored surfaces.

EXAMPLE NO. 5

Estimate the total heat transferred through an 8' x 10' vertical wall section at 4 p.m. on July 21. Assume the wall has an overall heat transfer coefficient of 0.02, west facing orientation, is lightly colored, and is located at 40°F latitude. Also assume an inside air temperature of 75°F and an outside air temperature of 94°F.

$$q_{cr} = UA\ (t_e - t_i)$$

$$= 0.02(8x10)(131-75)$$

$$q_{cr} = 89.6\ \text{Btu/hr}$$

1P-2A, 1-8

b. Windows and Transparent Surfaces

Solar radiation affects the heat gain through transparent surfaces in two ways. First, the combined conduction heat transferred is increased by the surface heating of the outside of the glass. Thus, the heat transferred by conduction is a function of the difference between sol-air temperatures and inside air temperatures. Second, is the solar heat gain inside the room by transmission. In summary, the total heat gain through glass areas equals the heat flow due to indoor-outdoor temperature differences plus the radiation transmitted through the glass.

The heat gain due to conduction is dependent upon the sol-air temperature, the indoor temperature, the overall heat transmission coefficient of the glass and the glass area. The solar heat gain by transmission is dependent upon the intensity of solar radiation, the orientation of the glass area with respect to the North, the degree of shading and the transmission coefficient of the glass.

6. ENERGY LOSSES AND GAINS FROM EQUIPMENT OPERATION

Heat is given off by many appliances and equipment, such as refrigerators, stoves, washing machines, dryers, freezers, dishwashers and lighting fixtures. This energy should be considered as advantageous to heating and may even reduce the size of your heating system. On the other hand, heat producing equipment adds to the cooling load.

Information Sheet #2B series 1-14

IP-2B, 1-1

Special Applications for Estimating Cooling Loads in Buildings

Cooling loads in buildings differ from instantaneous heat gain calculations because of flywheel effects. That is, some of the heat gained during the hottest portion of the day is stored in the building furnishings, walls and partitions and need not be removed until sometime later when the outdoor temperatures are lower and the instantaneous heat gain is smaller. Numerous techniques have been devised to account for this flywheel affect when calculating residential cooling loads.

Cooling loads are estimated by evaluating sensible cooling loads due to: (1) heat gain through floors, walls, ceilings; (2) windows; (3) infiltration and ventilation air exchange; and (4) occupancy. Then the latent cooling load (that required to control and remove excess moisture) is evaluated. A rule of thumb is to assume the latent cooling load is 0.3 times the sensible cooling load.

To help you understand the difference between heating loads and cooling loads, discussion is given under the following headings:

1. Cooling Load Due to Heat Gain Through Walls, Floors, Roofs and Ceilings.
2. Cooling Load Due to Windows.
3. Cooling Load Due to Infiltration.
4. Cooling Load Due to Occupancy.
5. Latent Cooling Load.
6. Total Cooling Load.

1. COOLING LOAD DUE TO HEAT GAIN THROUGH WALLS, FLOORS, ROOFS AND CEILINGS

The cooling load due to heat gain through structural components may be calculated by using an equivalent difference between the inside and outside temperatures in place of the actual indoor-outdoor temperature differences. Typical values of Equivalent Temperature Differences (ETD) are given in Table XVI. The ETD takes into account such factors as sol-air temperatures, construction type, thermal flywheel effects, and daily temperature ranges, and outdoor design temperatures. The cooling load due to structural components is obtained using equation (13):

$$q_{cs} = UA(ETD) \quad . \; . \; . \text{ Equation (13)}$$

To enter the table of ETD's, one must obtain both the outdoor design temperature and the range of daily temperatures for the building site (Table II). ETD's are given in 5°F increments of design temperatures from 85°F to 110°F (Table XVI). Daily temperature ranges are given for 3 conditions: L(0-15°F), M(15-25°F), and H(over 25°F). ETD's for design temperatures not listed can be obtained by adding 1°F to the tabulated value for each degree increase in design temperature. For this problem, walls are all assumed to be dark walls in Table XVI. Roofs, on the other hand, may be either dark or light colored.

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2. COOLING LOAD DUE TO WINDOWS

The equivalent temperature difference concept has also been adopted to simplify cooling loads due to heat gains through window areas. Typical values of equivalent temperature differences (ETD) are given in Table XVII. The ETD's are given for 4 types of glass (regular, single glass, regular double glass, heat absorbing double glass, and clear triple glass, 6 design temperatures (85 to 110°F), for 8 compass points (N, S, E, W, etc.), and for 4 window treatments (no drapes, draperies, roller shades, and awnings). The ETD's are based upon an indoor temperature of 75°F.

The cooling load for windows is then calculated using equation 13, as was done for walls.

Permanent shades, such as overhangs, will reduce the cooling load due to windows. Shaded windows are considered as North-facing windows to get ETD's. Most permanent shades will shade only a portion of the window area. Thus, it is necessary to determine the extent of shading, or the shade line, for each window. Table XXIII gives typical shade line factors for several latitudes and window orientation. The shade line will extend downward over the shaded wall for a distance equal to the shade line factor (from Table XVIII) times the overhang width. The shaded portion of the window is then assumed to be a North-facing window for its ETD while the orientation of the remaining portion of the window is not altered for its ETD. Note that NE and NW facing windows are not effectively protected by permanent shades.

3. COOLING LOAD DUE TO INFILTRATION

Infiltration and ventilation air exchanges are smaller in warm weather than in cold weather. The infiltration and ventilation cooling loads given in Table XIX reflect this difference. Infiltration cooling loads are obtained by multiplying the area of the exposed wall area times the factor given in Table XIX for a specific design temperature. Ventilation cooling load is calculated by multiplying the factor in Table XIX times the cfm capacity of the ventilation fans. Most residences do not have mechanical ventilation systems and rely upon infiltration for their ventilation.

4. COOLING LOAD DUE TO OCCUPANCY

The cooling load due to occupants and appliances is usually approximated. The load per occupant is approximately 225 Btu/hr and the number of occupants may be estimated at twice the number of bedrooms unless a lot of large group entertaining is anticipated.

The cooling load due to appliances in most residences can be limited to the kitchen and estimated at 1200 Btu/hr.

5. LATENT COOLING LOAD

The latent cooling load may be estimated at 20 to 30% of the sensible cooling load.

6. TOTAL COOLING LOAD

The total cooling load is the sum of the sensible cooling load through the structural components, windows, infiltration gains, occupancy gains, and moisture removal (latent cooling load).

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TABLE I. APPROXIMATE THICKNESS OF INSULATION FOR THERMAL RESIDENCES, IN.
(Reference, Cooling and Heating Load Calculation Manual, ASHRAE, 1979, Table 7.5, Page 7.21)

Thermal Resistance of Insulation	Batts or Blankets		Loose Fill			Boards and Slabs	
	Glass Fiber	Rock Wool	Glass Fiber	Rock Wool	Cellulosic	Polyurethane	Cellular Glass
R-7	2 1/4 to 2 3/4	2	3 to 4	2 to 3	2	1	2 5/8
R-11	3 1/2 to 4	3	5	4	3	1 3/4	4 1/4
R-13	3 5/8	3 1/2	6	4 to 5	4	2	5
R-19	6 to 6 1/2	5 1/4	8 to 9	6 to 7	5	3	7 1/4
R-22	6 1/2	6	10	7 to 8	6	3 1/2	8 3/8
R-30	9 1/2 to 10 1/2	9	13 to 14	10 to 11	8	4 3/4	11 3/8
R-38	12 to 13	10 1/2	17 to 18	13 to 14	10 to 11	6	14 1/2

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TABLE II. OUTSIDE DESIGN TEMPERATURES AND HEATING DEGREE-DAYS (65°F BASE) FOR DIFFERENT CLIMATIC LOCATIONS

(Adapted from Cooling and Heating Load Calculation Manual,
ASHRAE, 1979, Pages 2.3 and 7.16)

State and Station	Winter Design Dry-Bulb		Summer Design Dry-Bulb and Mean Coincident Wet-Bulb			Mean Daily Range	Heating Degree Days
	99%	97.5%	1%	2.5%	5%		
ALABAMA							
Huntsville AP	11	16	95/75	92/74	91/74	23	3,070
Mobile AP	25	29	95/77	93/77	91/76	18	1,560
ALASKA							
Fairbanks AP (S)	-51	-47	82/62	78/60	75/59	24	14,279
Kodiak	10	13	69/58	65/56	62/55	10	
ARIZONA							
Flagstaff AP	- 2	4	84/55	82/55	80/54	31	7,152
Phoenix AP (S)	31	34	109/71	107/71	105/71	27	1,765
ARKANSAS							
Fayetteville AP	7	12	97/72	94/73	92/73	23	
Little Rock AP (S)	15	20	99/76	96/77	94/77	22	3,219
CALIFORNIA							
Los Angeles AP (S)	41	43	83/68	80/68	77/67	15	2,061
San Francisco AP	35	38	82/64	77/63	73/62	20	3,001
COLORADO							
Denver AP	- 5	1	93/59	91/59	89/59	28	6,283
Leadville	-18	-14	84/52	81/51	78/50	30	
CONNECTICUT							
Bridgeport AP	6	9	86/73	84/71	81/70	18	5,617
Waterbury	- 4	2	88/73	85/71	82/70	21	
DELEWARE							
Dover AFB	11	15	92/75	90/75	87/74	18	
Wilmington AP	10	14	92/74	89/74	87/73	20	4,930
D.C.							
Andrews AFB	10	14	92/75	90/74	87/75	18	4,224
Wash Nat AP	14	17	93/75	91/74	89/74	18	

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TABLE II (Continued)

State and Station	Winter Design Dry-Bulb 99%	Winter Design Dry-Bulb 97.5%	Summer Design Dry-Bulb and Mean Coincident Wet-Bulb 1%	Summer Design Dry-Bulb and Mean Coincident Wet-Bulb 2.5%	Summer Design Dry-Bulb and Mean Coincident Wet-Bulb 5%	Mean Daily Range	Heating Degree Days
FLORIDA							
Gainesville AP	28	31	95/77	93/77	92/77	18	
Miami AP (S)	44	47	91/77	90/77	89/77	15	214
Tallahassee							1,485
GEORGIA							
Atlanta AP (S)	17	22	94/74	92/74	90/73	19	2,961
Waycross	26	29	96/77	94/77	91/76	20	
Thomasville							1,529
HAWAII							
Honolulu AP	62	63	87/73	86/73	85/72	12	
Wahiawa	58	59	86/73	85/72	84/72	14	
IDAHO							
Boise AP (S)	3	10	96/65	94/64	91/64	31	5,809
Idaho Falls AP	-11	- 6	89/61	87/61	84/59	38	
ILLINOIS							
Carbondale	2	7	95/77	93/77	90/76	21	
Chicago, O'Hare AP	- 8	- 4	91/74	89/74	86/72	20	6,639
INDIANA							
Fort Wayne AP	- 4	1	92/73	89/72	87/72	24	6,205
Indianapolis AP (S)	- 2	2	92/74	90/74	87/73	22	5,699
IOWA							
Des Moines AP	-10	- 5	94/75	91/74	88/73	23	6,588
Waterloo	-15	-10	91/76	89/75	86/74	23	7,320
KANSAS							
Manhattan, Fort Riley (S)	- 1	3	99/75	95/75	92/74	24	
Wichita AP	3	7	101/72	98/73	96/73	23	4,660
KENTUCKY							
Lexington AP	3	8	93/73	91/73	88/72	22	4,683
Louisville AP	5	10	95/74	93/74	90/74	23	4,660
LOUISIANA							
Natchitoches	22	26	97/77	95/77	93/77	20	
New Orleans	29	33	93/78	92/78	90/77	16	1,385

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Table II (Continued)

State and Station	Winter Design Dry-Bulb		Summer Design Dry-Bulb and Mean Coincident Wet-Bulb			Mean Daily Range	Heating Degree Days
	99%	97.5%	1%	2.5%	5%		
MAINE							
Caribou AP (S)	-18	-13	84/69	81/67	78/66	21	9,767
Lewiston	-7	- 2	88/73	85/70	82/68	22	
MARYLAND							
Baltimore CO	14	17	92/77	89/76	87/75	17	4,111
Frederick	8	12	94/76	91/75	88/74	22	
MASSACHUSETTS							
Boston AP (S)	6	9	91/73	88/71	85/70	16	5,634
Springfield, Westover AFB	- 5	0	90/72	87/71	84/69	19	
MICHIGAN							
Detroit	3	6	91/73	88/72	86/71	20	6,232
Sault Ste. Marie AP (S)	-12	- 8	84/70	81/69	77/66	23	9,048
MINNESOTA							
Intn'l Falls AP	-29	-25	85/68	83/68	80/66	26	
Minneapolis, St. Paul AP	-16	-12	92/75	89/73	86/71	22	8,382
MISSISSIPPI							
Biloxi, Keesler AFB	28	31	94/79	92/79	90/78	16	
Tupelo	14	19	96/77	94/77	92/76	22	2,041
MISSOURI							
Kansas City AP	2	6	99/75	96/74	93/74	20	4,711
St. Louis AP	2	6	97/75	94/75	91/74	21	4,900
MONTANA							
Bozeman	-20	-14	90/61	87/60	84/59	32	
Missoula AP	-13	- 6	92/62	88/61	85/60	36	8,125
NEBRASKA							
Lincoln CO (S)	- 5	- 2	99/75	95/74	92/74	24	5,864
Omaha AP	- 8	- 3	94/76	91/75	88/74	22	6,612
NEVADA							
Las Vegas AP(S)	25	28	108/66	106/65	104/65	30	2,709
Reno AP (S)	5	10	95/61	92/60	90/59	45	6,332

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Table II (Continued)

State and Station	Winter Design Dry-Bulb		Summer Design Dry-Bulb and Mean Coincident Wet-Bulb			Mean Daily Range	Heating Degree Days
	99%	97.5%	1%	2.5%	5%		
NEW HAMPSHIRE							
Keene	-12	- 7	90/72	87/70	83/69	24	7,383
Portsmouth, Pease AFB	- 2	2	90/73	85/71	83/70	22	
NEW JERSEY							4,500
NEW MEXICO							
Albuquerque AP(S)	12	16	96/61	94/61	92/61	27	4,348
Raton AP	- 4	1	91/60	89/60	87/60	34	6,228
NEW YORK							
NYC-Kennedy AP	12	15	90/73	87/72	84/71	16	5,219
Utica	-12	- 6	88/73	85/71	82/70	22	
NORTH CAROLINA							
Asheville AP	10	14	89/73	87/72	85/71	21	4,042
Raleigh/ Durham AP (S)	16	20	94/75	92/75	90/75	20	3,393
NORTH DAKOTA							9,000
OHIO							
Cincinnati CO	1	6	92/73	90/72	88/72	21	4,410
Cleveland AP (S)	1	5	91/73	88/72	86/71	22	6,351
OKLAHOMA							
Lawton AP	12	16	101/74	99/74	96/74	24	
Oklahoma City AP (S)	9	13	100/74	97/74	95/73	23	3,725
OREGON							
Pendleton AP	- 2	5	97/65	93/64	90/62	29	5,127
Portland AP	17	23	89/68	85/67	81/65	23	4,635
PENNSYLVANIA							
Philadelphia AP	10	14	93/75	90/74	87/72	21	5,144
Pittsburgh AP	1	5	89/72	86/71	84/70	22	5,987
RHODE ISLAND							
Newport (S)	5	9	88/73	85/72	82/70	16	
Providence AP	5	9	89/73	86/72	83/70	19	5,954

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Table II (Continued)

State and Station	Winter Design Dry-Bulb 99%	Winter Design Dry-Bulb 97.5%	Summer Design Dry-Bulb and Mean Coincident Wet-Bulb 1%	Summer Design Dry-Bulb and Mean Coincident Wet-Bulb 2.5%	Summer Design Dry-Bulb and Mean Coincident Wet-Bulb 5%	Mean Daily Range	Heating Degree Days
SOUTH CAROLINA							
Greenville AP	18	22	93/74	91/74	89/74	21	2,980
Spartanburg AP	18	22	93/74	91/74	89/74	20	
SOUTH DAKOTA							
Brookings	-17	-13	95/73	92/72	89/71	25	
Rapid City AP (S)	-11	- 7	95/66	92/65	89/65	28	7,345
TENNESSEE							
Knoxville AP	13	19	94/74	92/73	90/73	21	3,494
Memphis AP	13	18	98/77	95/76	93/76	21	3,232
TEXAS							
Amarillo AP	6	11	98/67	95/67	93/67	26	3,985
Dallas AP	18	22	102/75	100/75	97/75	20	2,363
Houston CO	28	33	97/77	95/77	93/77	18	1,278
UTAH							
Logan	- 3	2	93/62	91/61	88/60	33	
Salt Lake City AP (s)	3	8	97/62	96/62	92/61	32	6,052
VERMONT							
Barre	-16	-11	84/71	81/69	78/68	23	
Burlington AP (S)	-12	- 7	88/72	85/70	82/69	23	8,269
VIRGINIA							
Norfolk AP	20	22	93/77	91/76	89/76	18	3,421
Roanoke AP	12	16	93/72	91/72	88/71	23	4,150
WASHINGTON							
Seattle-Tacoma AP (S)	21	26	84/65	80/64	76/62	22	5,145
Spokane AP (S)	- 6	2	93/64	90/63	87/62	28	6,655
WEST VIRGINIA							
Morgantown AP	4	8	90/74	87/73	85/73	22	4,500
Wheeling	1	5	89/72	86/71	84/70	21	
WISCONSIN							
Ashland	-21	-21	85/70	82/68	79/66	23	7,635
Milwaukee AP	- 8	- 4	90/74	87/73	84/71	21	
WYOMING							
Cheyenne AP	- 9	- 1	89/58	86/58	84/57	30	7,381
Laramie AP (S)	-14	- 6	84/56	81/56	79/55	28	

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TABLE III. CONDUCTIVITY OF SOME BUILDING MATERIALS

(Adapted from Cooling and Heating Load
Calculation Manual, ASHRAE, 1979,
Page 3.4)

	Conductivity (k)
Hardboard, Medium Density	.73
Particleboard, Medium Density	.94
Polystyrene, Smooth Skin	.20
Glass Fiber, Organic Bonded	.25
Wood, Medium Density	1.49

TABLE IV. CONDUCTANCE OF SOME BUILDING MATERIALS

(Adapted from Cooling and Heating Load
Calculation Manual, ASHRAE, 1979,
Page 3.4)

	Thickness (in)	Conductance (C)
Plywood	.5	1.60
Carpet and Fiberous Pad	-	.48
Mineral Fiber	3.5	.053
Concrete Block, Sand and Gravel	8	.90
Asphalt Shingle		2.27

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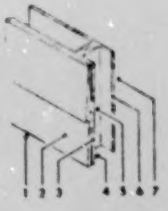
TABLE V. COEFFICIENTS OF HEAT TRANSFER (U) THROUGH FRAME WALLS*

*(Reference, Cooling and Heating Load Calculation Manual, ASHRAE, 1979, Table 3.2A, Page 3.8)

These U-coefficients are expressed in Btu per (hour) (square foot) (degree Fahrenheit difference in temperature between the air on the two sides), and are based on an outside wind velocity of 15 mph. The Heat Capacity Units are Btu/ft²·F



Replace Air Space with 3.5-in. R-11 Blanket Insulation (New Item 4)	1		2		1	2
	Resistance (R)				Heat Capacity	
Construction	Between Framing	At Framing	Between Framing	At Framing	Between Framing	
1. Outside surface (15 mph wind)	0.17	0.17	0.17	0.17	—	—
2. Siding, wood, 0.5 in.× 8 in. lapped (average)	0.81	0.81	0.81	0.81	0.47	0.47
3. Sheathing, 0.5-in. asphalt impregnated	1.32	1.32	1.32	1.32	0.23	0.23
4. Nonreflective air space, 3.5 in. (50 Fmean; 10 deg F temperature difference)	1.01	—	11.00	—	—	.08
5. Nominal 2-in. × 4-in. wood stud	—	4.38	—	4.38	—	—
6. Gypsum wallboard, 0.5 in.	0.45	0.45	0.45	0.45	0.54	0.54
7. Inside surface (still air)	0.68	0.68	0.68	0.68		
Total Thermal Resistance (R)	R_i=4.44	R_s=7.81	R_i=14.43	R_s=7.81	1.24	1.32

Construction No. 1: U_i = 1/4.44=0.225; U_s=1/7.81 =0.128. With 20% framing (typical of 2-in. × 4-in. studs @ 16-in. o.c.), U_{av} = 0.8 (0.225) + 0.2 (0.128) = 0.206 (See Eq 9)

Construction No. 2: U_i = 1/14.43 = 0.069; U_s = 0.128. With framing unchanged, U_{av} = 0.8(0.069) + 0.2(0.128) = 0.081

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TABLE VI. AIR EXCHANGES IN RESIDENCES FOR TYPICAL DESIGN CONDITIONS*
(Adapted from Tables 7.11A and 7.11B, Cooling and Heating Load Calculation Manual, ASHRAE, 1979, Page 7.23)

Type Room	Changes/Hour
Room w/o windows or exterior doors	0.5
Rooms with windows or exterior doors on one side	1.0
Rooms with windows or exterior doors on two sides	1.5
Rooms with windows or exterior doors on three sides	2.0
Entrance halls	2.0

*Use 2/3 of tabulated values for weatherstripped windows or storm sashes.

TABLE VII. RECOMMENDED VENTILATION AIR VOLUME FOR SINGLE FAMILY RESIDENCES
(Adapted from Cooling and Heating Load Calculation Manual, ASHRAE, 1977, Page 5.12)

Room	Ventilation Air Per Occupant Minimum (cu ft/min)	Ventilation Air Per Occupant Recommended (cu ft/min)
General living areas; bedroom, utility areas	5.0	7.0-10.0
Kitchens, bathrooms	20.0	30.0-50.0

TABLE VIII. SOL-AIR TEMPERATURES FOR JULY 21 AT 40°N LATITUDE
(Adapted from Fundamentals Handbook, 1977, ASHRAE, Page 25.5)

	Air	Light Surfaces					Dark Surfaces				
Time	Temp.	N	E	S	W	HOR	N	E	S	W	HOR
4	74	74	74	74	74	67	74	74	74	74	67
8	77	82	114	83	81	93	87	151	89	96	122
12	90	96	97	112	97	127	103	104	134	104	172
16	94	99	98	100	131	113	104	103	106	168	139
20	85	85	85	85	85	78	85	85	85	85	85
24	77	77	77	77	77	70	77	77	77	77	70
Avg.	83	86	91	89	91	91	89	100	85	100	107

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TABLE XVI. DESIGN EQUIVALENT TEMPERATURE DIFFERENCES (ETD) FOR WALLS, CEILINGS AND FLOORS
(Reference, Cooling and Heating Load Calculation Manual,
ASHRAE, 1979, Table 7.8, Page 7.22)

Design Temperature, deg F	85		90			95			100		105	110
Daily Temperature Range [a]	L	M	L	M	H	L	M	H	M	H	H	H
WALLS AND DOORS												
1. Frame and veneer-on-frame	17.6	13.6	22.6	18.6	13.6	27.6	23.6	18.6	28.6	23.6	28.6	33.6
2. Masonry walls, 8-in. block or brick	10.3	6.3	15.3	11.3	6.3	20.3	16.3	11.3	21.3	16.3	21.3	26.3
3. Partitions, frame	9.0	5.0	14.0	10.0	5.0	19.0	15.0	10.0	20.0	15.0	20.0	25.0
masonry	2.5	0	7.5	3.5	0	12.5	8.5	3.5	13.5	8.5	13.5	18.5
4. Wood doors	17.6	13.6	22.6	18.6	13.6	27.6	23.6	18.6	28.6	23.6	28.6	33.6
CEILINGS AND ROOFS [b]												
1. Ceilings under naturally vented attic or vented flat roof—dark	38.0	34.0	43.0	39.0	34.0	48.0	44.0	39.0	49.0	44.0	49.0	54.0
—light	30.0	26.0	35.0	31.0	26.0	40.0	36.0	31.0	41.0	36.0	41.0	46.0
2. Built-up roof, no ceiling—dark	38.0	34.0	43.0	39.0	34.0	48.0	44.0	39.0	49.0	44.0	49.0	54.0
—light	30.0	26.0	35.0	31.0	26.0	40.0	36.0	31.0	41.0	36.0	41.0	46.0
3. Ceilings under unconditioned rooms	9.0	5.0	14.0	10.0	5.0	19.0	15.0	10.0	20.0	15.0	20.0	25.0
FLOORS												
1. Over unconditioned rooms	9.0	5.0	14.0	10.0	5.0	19.0	15.0	10.0	20.0	15.0	20.0	25.0
2. Over basement, enclosed crawl space or concrete slab on ground	0	0	0	0	0	0	0	0	0	0	0	0
3. Over open crawl space	9.0	5.0	14.0	10.0	5.0	19.0	15.0	10.0	20.0	15.0	20.0	25.0

[a] Daily Temperature Range

L (Low) Calculation Value: 12 deg F.	M (Medium) Calculation Value: 20 deg F.	H (High) Calculation Value: 30 deg F.
Applicable Range: Less than 15 deg F.	Applicable Range: 15 to 25 deg F.	Applicable Range: More than 25 deg F.

[b] Ceiling and Roofs: For roofs in shade, 18-hr average = 11 deg temperature differential. At 90 deg F design and medium daily range, equivalent temperature differential for light-colored roof equals 11 + (0.71)(39 − 11) = 31 deg F.

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TABLE XVII. DESIGN COOLING LOAD FACTORS THROUGH GLASS (ETD)
(Reference, Cooling and Heating Load Calculation Manual,
ASHRAE, 1979, Table 7.6, Page 7.21)

Outdoor	Regular Single Glass						Regular Double Glass						Heat Absorbing Double Glass						Clear Triple Glass		
Design Temp	85	90	95	100	105	110	85	90	95	100	105	110	85	90	95	100	105	110	85	90	95
No Awnings or inside Shading																					
North	23	27	31	35	39	44	19	21	24	26	28	30	12	14	17	19	21	23	17	19	20
NE and NW	56	60	64	68	72	77	46	48	51	53	55	57	27	29	32	34	36	38	42	43	44
East and West	81	85	89	93	97	102	68	70	73	75	77	79	42	44	47	49	51	53	62	63	64
SE and SW	70	74	78	82	86	91	59	61	64	66	68	70	35	37	40	42	44	46	53	55	56
South	40	44	48	52	56	61	33	35	38	40	42	44	19	21	24	26	28	30	30	31	33
Horiz. Skylight	160	164	168	172	176	181	139	141	144	146	148	150	89	91	94	96	98	100	126	127	129
Draperies or Venetian Blinds																					
North	15	19	23	27	31	36	12	14	17	19	21	23	9	11	14	16	18	20	11	12	14
NE and NW	32	36	40	44	48	53	27	29	32	34	36	38	20	22	25	27	29	31	24	26	27
East and West	48	52	56	60	64	69	42	44	47	49	51	53	30	32	35	37	39	41	38	39	41
SE and SW	40	44	48	52	56	61	35	37	40	42	44	46	24	26	29	31	33	35	32	33	34
South	23	27	31	35	39	44	20	22	25	27	29	31	15	17	20	22	24	26	18	19	21
Roller Shades Half-Drawn																					
North	18	22	26	30	34	39	15	17	20	22	24	26	10	12	15	17	19	21	13	14	15
NE and NW	40	44	48	52	56	61	38	40	43	45	47	49	24	26	29	31	33	35	34	35	35
East and West	61	65	69	73	77	82	54	56	59	61	63	65	35	37	40	42	44	46	49	49	50
SE and SW	52	56	60	64	63	73	46	48	51	53	55	57	30	32	35	37	39	41	41	42	43
South	29	33	37	41	45	50	27	29	32	34	36	38	18	20	23	25	27	29	25	26	26
Awnings																					
North	20	24	28	32	36	41	13	15	18	20	22	24	10	12	15	17	19	21	11	12	13
NE and NW	21	25	29	33	37	42	14	16	19	21	23	25	11	13	16	18	20	22	12	13	14
East and West	22	26	30	34	38	43	14	16	19	21	23	25	12	14	17	19	21	23	12	13	14
SE and SW	21	25	29	33	37	42	14	16	19	21	23	25	11	13	16	18	20	22	12	13	14
South	21	24	28	32	36	41	13	15	18	20	22	24	11	13	16	18	20	22	11	12	13

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TABLE XVIII. SHADE LINE FACTORS FOR WINDOWS

(Reference, Cooling and Heating Load Calculation Manual, Table 7.7, Page 7.20)

Direction Window Faces	N Latitude, Deg						
	25	30	35	40	45	50	55
E/W	0.8	0.8	0.8	0.8	0.8	0.8	0.8
SE/SW	1.9	1.6	1.4	1.3	1.1	1.0	0.9
S	10.1	5.4	3.6	2.6	2.0	1.7	1.4

Note: Distance shadow line falls below the edge of the overhang equals shade line factor multiplied by width of overhang. Values are averages for 5 hr of greatest solar intensity on August 1.

TABLE XIX. SENSIBLE COOLING LOAD DUE TO INFILTRATION AND VENTILATION

(Reference, Fundamentals Handbook, ASHRAE, 1977, Table 38, Page 25.41)

Design Temperature, F	85	90	95	100	105	110
Infiltration, Btuh/ft^2 of gross exposed wall area	0.7	1.1	1.5	1.9	2.2	2.6
Mechanical ventilation, Btuh/cfm	11.0	16.0	22.0	27.0	32.0	38.0

FEEDBACK

Objective A Check

1. Thermal conductivity/coefficient of conductance/refund to amount of heat that will pass through one ft2 of homogeneous material one inch thick, in an hour, for each degree fahrenheit of temperature difference between the two surfaces.

2. Thermal conductance/coefficient of conductance/referred to amount of heat that will pass through one ft2 of a specified thickness rather than for a unit thickness of one inch, in one hour, for each degree fahrenheit of temperature difference between the two surfaces.

3. Thermal resistivity/reciprocal of thermal conductivity (K)/ materials resistance to heat flow per unit (inch) thickness.

4. Thermal resistance/reciprocal of thermal conductance (C)/ materials resistance to heat flow for a specified thickness/ the larger the "R" value the greater the thermal resistance.

5. Coefficient of transmission/reciprocal of the total thermal resistance (RT)/ amount of heat expressed in BTU's that will pass through a combination of materials and air spaces.

6. The resistance to heat transfer through a combination of materials and air spaces. (Sum of the resistance of each component of a material (such as a well section)).

7. Method to determine air infiltration whereby window, door, crack widths and lengths and the wind speeds can be estimated where upon air flow (infiltration) can be evaluated.

8. Method to determine air infiltration, tabulated by estimating the number of air changes occurring per hour, per room volume.

9. Outdoor ambient temperature plus sclar radiation intensity factor/te/replaces to value when determining qcr.

10. Equivalent Temperature Differences/ETD takes into account such factors as sol-air temperatures, conduction type, thermal fly wheel effects, and daily temperature ranges, and outdoor design temperatures used in equation qus = UA (ETD) to determine cooling load due to heat gain .

11. Symbol for sol-air temperature.

FEEDBACK (Continued)

Objective B Check:

1. c
2. e
3. a
4. j
5. f
6. b
7. g
8. i
9. d
10. k

1. C
2. A,B,C

PRINCIPLES AND PRACTICES OF HEAT LOSSES AND GAINS

IP-3. Seasonal Fuel Use and Costs

OBJECTIVE

This instructional package will help you to determine seasonal fuel use and costs of a home or small building. At the completion of this instructional package, you will be able to:

A. Identify, describe, and apply a formula for determining seasonal fuel use.

B. Identify, describe, and apply a method for calculating seasonal fuel cost.

RESOURCES

The following resource is provided for you to use in attaining the above objective:

Information Sheets:

IP-3A, 1-3 "Predicting Seasonal Fuel Use and Costs"

IP-3B, 1-6 "Estimating Seasonal Fuel Heat Loss"*

*This information can be found in USDOE Publication Providing for Energy Efficiency in Homes and Small Buildings, Part II; Determining Amount of Energy Lost or Gained in a Building, American Association for Vocational Instructional Materials, Technical Information Center, P.O. Box 62, Oak Ridge, Tennessee, 1980.

ACTIVITY

A. Review instructional package resources"Predicting Seasonal Fuel Use and Costs" and "Estimating Seasonal Heat Loss."

B. Estimate the amount of fuel and cost for a heating season after determining heat transfer specifics of a building.

I. Analyze and explain in writing two equations for calculating seasonal heat lost.

Equation A.1 = $H = \frac{24hd\ (ti-ta)}{ti-to}$

_____1. Where H =
_____2. Where h =
_____3. Where ti =
_____4. Where to =
_____5. Where 24 =
_____6. Where d =
_____7. Where ta =

Equation A.2 - $qs = \frac{q \times D \times 24}{\Delta T}$

_____1. qs =
_____2. q =
_____3. D =
_____4. Δ T =
_____5. 24 =

II. Write the equation for determining seasonal fuel use.

_____1. Equation for determining seasonal fuel use.

_____2. Example (Use Natural Gas as Fuel)

III. Describe in writing and by example the procedure for determining seasonal fuel costs.

_____1. Procedure for determining seasonal fuel costs.

_____2. Example (use natural gas as fuel and result example from previous activity - III).

Instructional Sheet # 3A series 1-3

ESTIMATING SEASONAL HEAT LOAD

The procedures described and illustrated thus far allow computation of the heat loss from a building when the outdoor temperatures are at the design, or some other specific, temperature. This occurs for only a few hours, or instants, during the heating season. The seasonal heating load can be estimated by evaluating heat losses on an hour by hour basis. However, this procedure would be too time consuming. Instead, an approximate method known as the Degree-Day Method has been recommended by ASHRAE for predicting seasonal heat losses and fuel consumption.

The Degree Day Method estimates seasonal heating loads by assuming there is no heat loss or gain when the outdoor temperature is 65°F and then predicting from weather data the number of hours in the heating season for which the outdoor temperature is below 65°F. The total number of hours for which the outdoor temperature is less than 65°F is called the number of Degree Days for the building location. The number of degree days is dependent upon climate. Typical values are summarized for several locations in Table II.

The seasonal heat loss is estimated by the equation:

$$q_s = \frac{q \times D \times 24}{\Delta t}$$

where q_s = seasonal heat loss, Btu
q = heat loss at design temperatures, Btu/hr
D = number of degree days, F. days
Δt = design temperature difference, °F
24 = 24 hour day

To estimate the fuel consumption during a heating season, the heating value of the fuel and several efficiency factors must be applied to the seasonal heat loss value, q_s.

$$E = q_s \frac{C_D \times C_F}{\gamma \times v}$$

where E = seasonal fuel or energy consumption
C_D = correction factor heat loss differences
C_F = correction factor for partial loads for fuel-fired systems. (Use 1.0 for electric resistance heating.)
γ = rated full load efficiency of heating equipment (decimal value).
v = heating value of fuel in units consistent with E and q_s. (Btu/gal, Btu/cu. ft, Btu/kwh)

Suggested values of C_D and C_F are found in Tables XIV and XV. Full load efficiencies are usually between 70% and 80% and are available from manufacturers.

EXAMPLE NO. 7. SEASONAL HEAT LOAD ESTIMATION.

Consider the same situation described in Example Problem No. 1. Assume the heating system has a capacity of 30,000 Btu/hr.

Step 1: Evaluate the seasonal heat loss.

$$q_s = \frac{q \times D \times 24}{\Delta t}$$

q = 25,330 Btu/hr

D = 5144 degree days (Table II)-see IP #2
Δt = 65°-14° = 51°F

1 P-3A, 1-2

Thus $q_s = \frac{25,330 \times 5,144 \times 24}{51}$

$= 61,300,000$ Btu/season.

Step 2: Evaluate the quantity of fuel required per heating season.

$$E = q_s \frac{C_D \times C_F}{\gamma \times v}$$

$C_D = 0.83$ (Table XIV at 14°F design temperature).

$C_F = 1.56$ (Table XV for 25% oversized heating unit.)

γ = Efficiency .75, fuel oil; 1.00 electricity.

$v = 800$ Btu/ft^3 gas.

$v = 144,000$ Btu/gal fuel oil

$v = 3,413$ Btu/kwh electrical energy.

Thus the estimated quantity of fuel consumed is

$E = 61,300,000 \left(\frac{0.83 \times 1.56}{0.75 \times 800}\right) =$ 132,000 cu. ft. gas.

$E = 61,300,000 \left(\frac{0.83 \times 1.56}{0.75 \times 144,000}\right) =$ 735 gal. fuel oil

$E = 61,300,000 \left(\frac{0.83 \times 1.56}{1.0 \times 3413}\right) =$ 23,250 KWh electrical energy.

1P-3A, 1-3

TABLE XIV. CORRECTION FACTORS FOR HEAT LOSS VS. DEGREE DAYS INTERIM FACTOR C_Da

(Reference Systems Handbook, ASHRAE, 1976, Page 43.8)

Outdoor Design Temp, F	-20	-10	0	+10	+20
Factor C_D	0.57	0.64	0.71	0.79	0.89

*The multipliers in Table 2 which are high for mild climates and low for cold regions, are not in error as might appear. For equivalent buildings, those in warm climates have a greater portion of their heating requirements on days when the mean temperature is close to 65 F, and thus the actual heat loss is not reflected.

TABLE XV. PART LOAD CORRECTION FACTOR (C_F) FOR FUEL-FIRED EQUIPMENT

(Reference, Systems Handbook, ASHRAE, 1976, Page 43.8)

Percent oversizing	0	20	40	60	80
Factor C_F	1.36	1.56	1.79	2.04	2.32

*Because equipment performance at extremely low loads is highly variable, it is strongly recommended that the values in Table 3 not be extrapolated.

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PREDICTING FUTURE NEEDS*

Once the heat loss for a room or home has been determined, the fuel costs for heating season can be estimated. Determining the heating costs of various systems will give an idea of which fuel and system will provide the home with the greatest comfort for the money spent. Note also that heating costs can vary according to how well the house has been weatherized.

If the heat loss calculations for a building were accurate for the design conditions, and if the heat loss at any other outside temperature were proportional to that at design conditions, then the heat loss from the building for a whole heating season could be expressed by the equation:

---

*Source: Storck & Koral: Handbook of Air Conditioning, Heating and Ventilating - 2nd Edition, Published 1959, 1965 by Industrial Press, Inc. Reprinted with permission.

IP-3B, 1-2

$$H = \frac{24hd(t_i-t_a)}{t_i-t_o}$$

where H = seasonal heat loss in BTU,

h = hourly heat loss from the building for the design conditions, BTU,

t_i = inside design temperature, deg F,

* t_o = outside design temperature, deg F,

24 = hours per day,

* d = number of days in the heating season,

t_a = average outside temperature for the heating season.

* (See Appendix A & B in back of this unit for Figures.)

For buildings where the inside design temperature is 70 deg, the formula becomes:

$$H = \frac{24hd(70-t_a)}{70-t_o}$$

EXAMPLE

What would be the heat required for a residence in New York where the design heat loss is 70,000 BTU per hour, d=241, t_a=44.0 degrees, t_o=0 degrees and the t_i=70 degrees?

Substituting in the equation above:

$$H = \frac{24 \times 70{,}000 \times 241 \times (70-44)}{(70-0)}$$

H = 150,384,000 BTU the heat loss for the whole heating season

Determining Fuel Use

The heat loss for the whole heating season can be converted into fuel units by dividing by the heat value per fuel unit and by the utilization efficiency. For example, assuming 1031 BTU per cubic foot of natural gas at 75% efficiency, the gas consumption per season would be:

IP-3B, 1-3

$$\text{fuel use} = \frac{150{,}384{,}000}{1031 \times .75}$$

$$= \frac{150{,}384{,}000}{773.25}$$

$$= 194{,}483 \text{ cu. ft.}$$

HEAT VALUE/COST/EFFICIENCY PER FUEL

Fuel	Heat Value (BTU)	Approximate Cost*	Efficiency (%)
Natural Gas	1031/cubic foot	$3.00/mcf	75
#1 Heating Oil	136,000/gallon	.592/gallon	75
#2 Heating Oil	140,000/gallon	.66/gallon	75
Bottle Gas Propane	93,000/gallon	.558/gallon	75
High Volatile Bituminous Coal	26,000,000/ton	45.00/ton	65
Electric Resistance Heat	3412/kilowatt	.05/kwh	100

*Estimated Average Cost July, 1979 Morgantown, West Virginia

Determining Fuel Cost

The cost of the fuel for the entire heating season can be determined by multiplying the fuel use unit by the fuel cost. For example, assuming 194,483 cubic feet of natural gas at $3.00 per thousand cubic feet of gas, the gas cost per season would be

= 194.483 x $3.00

= $583.449 per heating season

EXAMPLES FOR VARIOUS FUEL

$$\text{Heat Loss} = \frac{24 \times 32{,}787 \times 238\ (70 - 40)}{70 - 5}$$

$$= \frac{187{,}279{,}344 \times 30}{65}$$

IP-3B, 1-4

$$= \frac{5.618380320}{65}$$

= 86,436,620 BTU's required for one heating season

NATURAL GAS $\frac{86,436,620}{.75 \times 1031 \text{ BTU/Cu. Ft.}}$ = 111783.53 Cubic Feet of Gas

MCF = $\frac{111783.53}{1000}$

= 111.78 MCF

cost = MCF x $3.00
= 111.78 x $3.00
= $335.35 per heating season

#1 HEATING OIL $\frac{86,436,620}{.75 \times 136,000 \text{ BTU/Gal.}}$ = 847.41 Gallons of oil

cost = gallon x .592
= 847.42 x .592
= $501.67 per heating season

#2 HEATING OIL $\frac{86,436,620}{.75 \times 140,000 \text{ BTU/Gal.}}$ = 823.20 Gallons of oil

cost = gallon x .66
= 823.20 x .66
= $543.31 per heating season

BOTTLE GAS PROPANE $\frac{86,436,620}{.75 \times 93,000 \text{ BTU/Gal.}}$ = 1213.14 Gallons of Propane

cost = gallon x .558
= 1213.14 x .558
= $676.93 per heating season

COAL $\frac{86,436,620}{.65 \times 26,000,000 \text{ BTU/Ton}}$ = 5.11 Tons of Coal

cost = Tons x $45.00
= 5.11 x 45.00
= $230.15 per heating season

ELECTRIC $\frac{86,436,620}{1.00 \times 3412/\text{KW}}$ = 25,333 KW

cost = KW x .05 = 25,333 x .05 = $1266.65 per heating season

1P-3B,1-5

APPENDIX A

Air Conditioning Design Data*

(Delaware, District of Columbia, Maryland,
Pennsylvania, Virginia, West Virginia)

State & Station	Winter Dry Bulb Temp.(f)	Summer Dry Bulb Temp.(f)
DELAWARE:		
Bethany Beach	20	87
Dover AFB	15	90
Lewes	19	87
Miles, Fort	19	87
Wilmington	11	90
DISTRICT OF COLUMBIA:		
Andrews AFB, Walter Reed Hosp	16	91
National Arpt	17	93
MARYLAND:		
Annapolis USNA	16	86
Baltimore Aprt	15	91
Bethesda Naval Medical Ctr.	17	92
Chesapeake Beach NRL	19	88
Cumberland	11	90
Frederick	9	91
Hagerstown	6	90
Ocean City	20	87
PENNSYLVANIA:		
Allentown	12	89
Altoona	0	87
Beaver Falls	8	89
Bethlehem	12	89
Brookville	0	87
Clarion	-1	90
Clearfield	0	91
Columbia	5	91
Connellsville	3	87
DuBois	0	87
Erie	6	85
Geneva	2	90
Harrisburg	14	92
Hazleton	8	85
Johnstown	6	87
Lancaster	5	91
Latrobe	8	89
Mechanicsburg	14	92
New Castle	4	90
Oil City	0	90
Phillipsburg	-2	85
Pittsburgh	9	87
Reading	14	90
St. Marys	-3	88
Uniontown	8	89
Waynesburg	6	89
Williamsport	7	89
York	14	92
VIRGINIA:		
Bedford	15	92
Belvoir, Fort	17	91
Blackstone	19	92
Bowling Green	18	94
Cape Henry	24	92
Charlottesville	15	90
Covington	18	91
Dulles Int Arpt	13	91
VIRGINIA (Continued)		
Fishersville	15	90
Hampton	22	92
Lynchburg	18	89
Marion	14	88
Myer, Fort	17	93
Newport News	22	92
Norfolk	25	91
Northwest	25	92
Petersburg	18	94
Richmond	18	94
Roanoke	18	91
Staunton	15	90
Virginia Beach	24	92
Williamsburg	19	91
Yorktown	22	92
WEST VIRGINIA:		
Beckley	6	88
Bluefield	11	88
Charleston	14	90
Clarksburg	7	91
Elkins	5	84
Fairmont	7	91
Huntington	18	93
Martinsburg	7	93
Morgantown	11	88
Parkersburg	11	90
Ripley	10	93
Wheeling	9	87

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*Source: Starck & Koral: Handbook of Air Conditioning, Heating and Ventilating - 2nd Edition, Published 1959, 1965 by Industrial Press, Inc. Reprinted with permission.

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1P-3B, 1-6

APPENDIX B

Data on Normal Heating Season*

(Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, West Virginia)

State & Station	Average Date Season Begins	Average Date Season Ends	Day Per Season	Average Temp. Degree F.	No. of Degree Days
DELAWARE:					
Dover+	Sept 25	May 20	238	45.7	4591
Milford+	Sept 28	May 17	232	46.5	4303
Wilmington-A	Sept 27	May 19	235	44.1	4910
DISTRICT OF COLUMBIA:					
Washington-A	Oct 2	May 14	225	45.7	4333
Washington-C	Oct 2	May 12	223	45.9	4258
Silver Hill Obs.	Sept 20	May 17	232	45.4	4539
MARYLAND:					
Annapolis+	Sept 24	May 17	236	46.0	4483
Baltimore-A	Sept 28	May 19	234	45.3	4611
Baltimore-C	Sept 8	May 13	248	48.1	4203
Cambridge+	Oct 1	May 13	225	46.1	4245
Frederick-A	Sept 29	May 16	23[illegible]	43.9	4854
PENNSYLVANIA:					
Allenton-A	Sept 18	May 26	251	41.6	5880
Altoona+	Sept 8	Jun 7	273	42.6	6121
Coatesville+	Sept 19	May 26	250	43.7	5365
Erie-C	Sept 20	Jun 4	258	41.3	6116
Franklin+	Sept 5	Jun 11	280	42.2	6383
Harrisburg-A	Sept 22	May 20	241	43.2	5258
Lancaster+	Sept 13	May 27	257	43.7	5482
Lebanon+	Sept 16	May 28	255	43.1	5585
New Castle+	Sept 12	May 30	261	42.2	5958
Philadelphia-A	Sept 28	May 19	234	44.2	4866
Philadelphia-C	Oct 2	May 17	228	45.2	4523
Pittsburgh-Gr. Pitt.-A	Sept 19	May 29	253	41.7	5905
Pittsburgh-C	Sept 28	May 19	234	43.4	5048
Reading-C	Sept 26	May 21	238	43.7	5060
Scranton-C	Sept 15	May 30	258	41.6	6047
Uniontown+	Sept 10	May 24	257	44.9	5176
Warren+	Sept 2	Jun 18	290	41.8	6740
Williamsport-A	Sept 18	May 28	253	41.7	5898
York+	Sept 16	May 26	253	43.5	5449
VIRGINIA:					
Cape Henry-C	Oct 12	May 12	213	49.5	3307
Charlottesville+	Sept 17	May 12	238	47.3	4223
Danville+	Oct 8	May 6	211	48.4	3511
Lynchburg-A	Sept 29	May 12	226	46.6	4153
Norfolk-A	Oct 8	May 11	216	49.0	3454
Norfolk-C	Oct 13	May 7	207	49.9	3119
Richmond-A	Oct 4	May 12	221	47.1	3955
Richmond-C	Oct 6	May 9	216	47.8	3720
Roanoke-A	Oct 1	May 14	226	46.6	4152
Wytheville+	Sept 13	Jun 2	263	45.9	5022
WEST VIRGINIA:					
Charleston-A	Oct 1	May 17	229	45.7	4417
Elkins-A	Sept 12	Jun 6	268	43.5	5773
Fairmont+	Sept 20	May 23	246	44.5	5047
Huntington-C	Oct 4	May 11	220	46.5	5047
Parkersburg-C	Sept 30	May 18	231	44.4	4750
Petersburg-C	Sept 23	May 22	242	44.5	4966
Wheeling+	Sept 19	May 21	276	46.1	5218

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*Source: Storck & Koral: Handbook of Air Conditioning, Heating and Ventilating - 2nd Edition, Published 1959, 1965 by Industrial Press, Inc. Reprinted with permission.

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FEEDBACK

Objective A Check:

Equation A.1

1. H = seasonal heat loss in BTU
2. h = hourly heat loss from the building for the design conditions
3. ti = inside design temperature, degrees F.
4. to = outside design temperature, degrees F.
5. 24 = hours per day
6. d = number of days in the heating season
7. ta = average outside temperature for the heating season

Equation A.2

1. qs = seasonal heat loss in BTU
2. q = heat loss at design temperature, BTU/HR
3. D = number of degree days, F. days
4. T = design temperature difference, F.
5. 24 = 24 hour day

Objective B Check:

1. $$E = qs\ \frac{CD \times CF}{\Upsilon \times v}$$

   E = seasonal fuel or energy consumption

   CD = convection factor heat loss differences

   CF = convection factor for partial loads for fuel

   Υ = rated full load efficiency of heating equipment (decimal value)

   V = heating value of fuel

2. Each example will vary.

3. The cost of the fuel for the entire heating season can be determined by multiplying the fuel use unit by the current fuel cost.

   For example, assuming 12,000 cubic feet of natural gas at $3.00 per thousand cubic feet of gas, the gas cost per season would be:

   $$MCF = \frac{12,000\ ft3}{1,000}$$

   $$= 1,200\ MCF$$

   Cost = MCF x cost of fuel

   = 1200 x $3,00

   = $360.00/heating season

POST-CHECK

PRINCIPLES AND PRACTICES OF HEAT LOSSES AND GAINS

Apply all formulas and principles acquired in this module to complete this Post Check.

Using the sample wall section shown in Figure 1. and other information stated, determine the following: (show all calculations and formulas)

_____A. Determine total R.

_____B. Determine U

_____C. Determine ΔT.

_____D. Calculate qc.

_____E. Determine qi of room

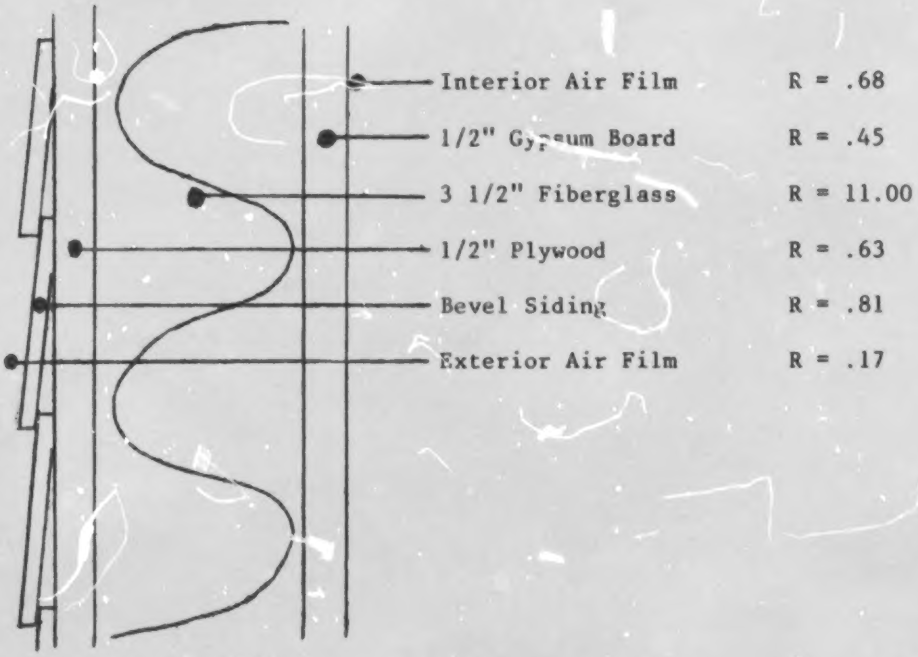
_____F. Calculate total Q.

_____G. Calculate qs.

_____H. Calculate E.

_____I. Calculate seasonal fuel cost.

FIGURE 1. FOR POST-CHECK


Interior Air Film R = .68
1/2" Gypsum Board R = .45
3 1/2" Fiberglass R = 11.00
1/2" Plywood R = .63
Bevel Siding R = .81
Exterior Air Film R = .17

Home Information

Ti = 65°F
To = 20°F
1 1/2 Air Changes
Room Dimensions 20'x10'x8' = 480 Ft
D = 5000
Heating Source. Electric Base Board @ $.04/KWH

POST-CHECK KEY

PRINCIPLES AND PRACTICES OF HEAT LOSSES AND GAINS

A. $.68 + .45 + 11.00 + .63 + .81 + .17 = 13.74$

B. $1/13.74 = .0727$

C. $Ti - To = \Delta T \quad (65^{\circ} - 20^{\circ} = 45^{\circ}) \quad \Delta T = 45^{\circ}$

D. $qc = U \times A \times \Delta T \quad .0727 \times 480\ Ft^{2} \times 45^{\circ} = 1570.32$ BTU/HR

E. $qi = (0.018)\ Qi(\ \ T) \quad 0.018 \times 2400 \times 45^{\circ} = 1944$ BTU/HR
qi = Air exchange x volume

F. $Q = qc + qi \quad 1570.32 + 1944 = 3514.32$ BTu/HR

G. $qs = \dfrac{q \times D \times 24}{\Delta T} = \dfrac{3514 \times 500 \times 24}{45} = 9,371,520$ BTU

H. $E - qs \ \dfrac{cb \times CF}{X \times V} = 9,371,520 \ \dfrac{.89 \times 1.56}{1.0 \times 3413} = \dfrac{1.3884}{3413} = 3812$ KWH

I. E x Fuel Cost per Unit = Seasonal Fuel Cost
3812 @ \$.04/KWH = \$152.49

6

MODULE ELEVEN

MEASURE HEAT LOSS AND GAIN

Prepared

by

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MEASURE HEAT LOSS AND GAIN

This module is designed to allow a student to teach himself, at his own pace, the techniques involved in performing an energy audit on a residential building. The student can, at his option, indicate to the teacher that he possesses the knowledge necessary to perform energy audits by taking the pretests at the beginning of each instructional package. A grade of 90% or better indicates the student's mastery of the techniques involved. A lesser grade indicates that the student needs to study all of the instructional packages.

The techniques described herein are by no means exhaustive; the represent a simplified approach to energy auditing designed to acquaint the student with the methods used and not to make him expert. It is suggested to use the included format in all calculations.

TERMINAL PERFORMANCE OBJECTIVE

At the conclusion of this module, the learner will be able to perform an energy audit on his/her house, or on one of several examples, and to critically evaluate the results. The learner will employ techniques discussed in Module Ten, and in DOE Publication IR/06065-1 Pt. 1., "Providing for Energy Efficiency in Homes and Small Buildings." To simplify the arithemtic involved, it is suggested to round off to whole numbers.

INSTRUCTIONAL PAKCAGES		KNOW	NEED
IP-1	Calculating Seasonal Heating Load	____	____
IP-2	Calculating Seasonal Cooling Load	____	____
IP-3	Evaluating Energy Audit	____	____

PRE-CHECK

MEASURE HEAT LOSS AND GAIN

Directions: Place the letter opposite each numbered test item that best completes the statement.

IP-1. Calculate Seasonal Heating Load

_____1. Thermal transmission coefficient is expressed as:

A. "R"
B. "U"
C. "K"
D. "T"

_____2. "ΔT" is a symbol for:

A. Sum of inside temperature and outside design temperature
B. Thermal conductance
C. Number of Degree-Days
D. Difference between inside temperature and outside design temperature

_____3. "Degree-Days" refer to:

A. College graduation
B. Number of hours the outside temperature is below 65°F.
C. Number of days the outside temperature is below 65°F.
D. Seasonal fuel consumption

_____4. Qc = U __?__ T

A. D
B. C
C. A
D. R

_____5. Given the Qc = 70,000, Δ = 2,500 and ΔT = 70, then U =

A. 12,230,000
B. .4
C. .04
D. 12.25

PRE-CHECK (Continued)

MEASURE HEAT LOSS AND GAIN

IP-2. Calculating Seasonal Cooling Load

_____1. "ETD" refers to:

A. Estimated Time of Departure
B. Environmental Teaching Department
C. Efficient Thermal Depletion
D. Estimated Temperature Difference

_____2. "Q" values are stated in:

A. BTU/Hr.
B. KC/Day
C. BTU
D. KC

_____3. Seasonal cooling load is found using which equation?

A. $Qs - U\Delta\ \Delta T$
B. $Qx = U\Delta\ (ETD)$
C. $Qs = Qc \times D\text{-}Dc \times 24/\Delta T$
D. $Qs = MC^2$

_____4. Cooling loads consist of:

A. Latent and sensible
B. Daytime and nighttime
C. Infiltration and validation
D. Inside and outside

_____5. In determining cooling loads, Q values are stated in:

A. therms
B. joules
C. BTU/hr.
D. megawatts

IP-3. Evaluating Energy Audit

_____1. An energy audit is performed:

A. To determine seasonal heating load
B. To determine seasonal cooling load
C. To determine energy consumption
D. All of the above

_____2. Low "Q" values indicate:

A. An efficient house
B. An inefficient house

PRE-CHECK (Continued)

MEASURE HEAT LOSS AND GAIN

_____3. Which of the following would be the simplest method of decreasing the heating/cooling load of a building?

A. Increase "R" values
B. Decrease " " values
C. Decrease "ΔT" values

_____4. The single biggest consumer of energy in a home is:

A. Domestic Hot Water
B. Lighting
C. Space Heating

_____5. Which building component has the least resistance to heat flow?

A. Doors and windows
B. Walls
C. Ceilings
D. Floors

PRE-CHECK KEY

MEASURE HEAT LOSS AND GAIN

IP-1. Calculating Seasonal Heating Load

1. B
2. D
3. B
4. C
5. B

IP-2. Calculating Seasonal Cooling Load

1. D
2. A
3. C
4. A
5. C

IP-3. Evaluating Energy Audit

1. D
2. A
3. A
4. C
5. A

MEASURE HEAT LOSS AND GAIN

IP-1. Calculating Seasonal Heating Load

OBJECTIVE

Upon completion of this instructional package, you will be able to:

A. Determine thermal resistance (R) and composite transmission coefficient (U=1/r) for the building envelope, including walls, ceiling, floors, doors, and windows.

B. Calculate Surface area (Δ) of the appropriate walls, ceilings, floors, doors, and windows.

C. Compute " T" after determining both the desired inside temperature and the outside design temperature.

D. Find air exchange rates (Qi) from appropriate tables.

E. Calculate heat ton by conduction and infiltration through the building envelope using the formula:

$Qc = UA/\ T \ \& \ .018\ Qi \Delta T$

F. Calculate seasonal heating load using the formula

$$Qc = \frac{Qc \times DD \times 24}{\Delta T}$$

RESOURCES

Books:

Solar Concepts. Gosham, J. Maine Audobon Society, 1979.

From the Walls in. Wing, C. Little, Brown, and Co., 1979.

From the Ground Up. Wing, C. and J. Cole. Little, Brown, and Co., 1976.

DOE/IR/06063-Pt. II
Providing for Energy Efficiency in Homes and Small Buildings

Module 10 in this series of modules.

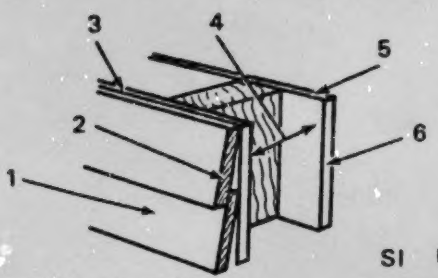
NOTE: There are a great number of books and journals dealing with the concept and techniques described herein. It is emphatically suggested to go to the library and/or bookstore and peruse them!

also: ASHRAE Handbook

ACTIVITY

A. Review one or more of the instructional resources listed for this package.

B. Make a list of all materials making up the walls of the house under audit. Beside each material write the associated "R" factor. Add the "R" factors and take the reciprocal of the sum to find "U."



	SI	US
1. THIN AIR FILM ON OUTSIDE WALL	.34	(.2)
2. WOOD SIDING MATERIAL	.14	(.8)
3. INSULATING SHEATHING ½ INCH THICK	.18	(1.0)
4. AIR SPACE BETWEEN STUDS	.18	(1.0)
5. GYPSUM WALLBOARD ½ INCH THICK	.09	(.5)
6. THIN AIR FILM ON INSIDE OF WALL	.12	(.7)
^{R}TOTAL	0.75	(4.2)

Exterior Air Film

1/2" Bevel Siding

1" Beaver Board

Air Space Between Studs

1/2 Gypsum Board

Interior Air Film

$$U = \frac{1}{R1 + R2 + R3 + R4 + R5 + R6}$$

C. Repeat this procedure for ceilings, floors, doors, and windows.

D. Make a list of appropriate ceilings, walls, doors, windows, and floors (i.e. those making up the building envelope.) Beside each record the surface area "A."

E. Establish the desired indoor temperature and record this figure. Find the outside design temperature for your area on an appropriate chart, and record this figure. The difference between the outside temperature and the inside temperature is recorded as "ΔT."

F. For air exchange rates (Qi) gain from a table. Record this figure.

ACTIVITY (Continued)

G. Find the heat loss through each building component by plugging these values into the formula - $Q = UA \Delta T$. Add the components together to find the total heat loss via conduction. Record this figure.

H. Plug "Qi" values into the formula $.018\ Qi\, \Delta T$. Add this value to the figure from activity G.

This value, Qc, indicates heat loss from the building when the outdoor temperature is at the design temperature. In order to estimate the seasonal heating load, a far more valuable bit of information, a method known as the "Degree-Day Method" is used. One additional value must be obtained in order to perform this simple calculation:

I. Find the number of "Degree-Days" (D-D) typical for your area from a map or a table. Using the values obtained previously, apply them in the following formula:

$$Q\ \text{Seasonal} = \frac{Q \times D\text{-}D \times 24}{\Delta T}$$

Q = Heat loss at design temperature, BTU/HR

Qs = Seasonal heating load

D-D = Number of Degree-Days, F. day

ΔT = Design temperature difference

24 = 24 hour day

Record this figure with proper units

NOTE: Example of this problem is worked on page 31-32, Part II, Providing Energy Efficiency in Homes and Small Buildings.

FEEDBACK

Objective A-F Check:

1. Upon completion of the activities listed for 1P-1, meet with your instructor to go over your calculations and to ask any questions you may have.

2. Retake the pre-check to see if you have reached the objectives as stated.

IP-2. Calculate Seasonal Cooling Load

OBJECTIVE

Upon completion of this instructional package, you will be able to:

A. Determine Equivalent Temperature Differences for each component using appropriate tables.

B. Calculate Total Cooling Loads.

C. Estimate Seasonal Cooling Loads.

RESOURCES

Same as IP-1 Calculating Seasonal Heating Load.

ACTIVITY

Some of the values obtained from 1P-1 are used in the calculation for Total Cooling Load: "R" values ($U=1/R$) and Δ, surface area. ΔT is replaced with Equivalent Temperature Difference (ETD).

A. Obtain the outside design temperature and the daily range of temperatures from an American Society for Heating, Refrigeration, and Air Conditioning (ASHRAE) table. (Cooling and Heating Load Calculations Manual, p. 23 and 7.16)

B. Determine the ETD for each component of the building from an appropriate table. (ASHRAE, p. 7.8 and 7.22)

C. Using the equation $Qcs = U\Delta(ETD)$, calculate the conduction Sensible Cooling Load for each building component. Add the components to arrive at a total. Record this figure.

D. Find the infiltration Sensible Cooling Load by using an appropriate table (ASHRAE p. 25-41).

E. Add the figure from "D" to the figures from "C" to arrive at the total cooling load. Record this figure.

F. Seasonal Cooling Load for the building under audit is estimated by using the "Cooling Degree-Day Method." This method is similar to the "Degree-Day Method" for estimating Seasonal Heating Load. Instead of using the value "D-D" obtained in Activity I of 1P-1. Replace it with "D-Dc," which can be obtained from appropriate tables. (Available from National Climate Centre, Asheville, NC.) Using the following formula, estimate Seasonal Cooling Load.

$$Qcs = \frac{Qcs \times (D-Dc) \times 24}{\Delta T}$$

Qcs = Seasonal Cooling
D-Dc = Degree Days Cooling
Where ΔT in this case is taken to be $15^{\circ}F$ ($90^{\circ} - 75^{\circ} = 15^{\circ}$)

FEEDBACK

Objective A-C Check:

1. Upon completion of the activities, meet with your instructor to go over your calculations and to ask any questions you may have.

2. Retake the pre-check to see if you have reached the objectives as stated.

MEASURE HEAT LOSS AND GAIN

IP-3. Evaluating Energy Audit

OBJECTIVES

You have now calculated both Seasonal Heating Load and Seasonal Cooling Load for either a real or imaginary building. Upon completion of this instructional package, you will be able to:

A. Evaluate the importance of thermal resistance, building area, and inside vs. outside temperatures in the efficient heating and cooling of a building.

B. Identify measures that could decrease the heating and cooling loads for the building under audit.

RESOURCES

Same as IP-1 and IP-2.

ACTIVITIES

A. Review one or more of the listed references for this instructional package.

B. Inquire of neighbors and friends who have improved the energy efficiency of their homes the techniques they used, and relate your findings to the class or to the instructor.

C. Make a list of ways you think might improve the energy efficiency of your home.

D. Bring into class information on efficiently designed buildings gleaned from magazines, journals, and local newspapers. Decide what factors (U.A. or T) have been most influential in the efficiency of the design. Share your thoughts with the class and your instructor.

FEEDBACK

Objective A-D Check:

1. Meet with your instructor concerning activities B, C, and D. Ask any questions you may have and bring up any points you feel are important.

2. Retake the pre-check.

POST-CHECK

MEASURE HEAT LOSS AND GAIN

1. A building measures 24x36 with an 8' ceiling. Construction details are as drawn. Compute seasonal heating load. (There are no windows or doors.) NOTE: Use Sample Format

This building is located in Boston, Massachusetts. Show all work. Round off to whole numbers. Check your answer with the instructor.

POST-CHECK (Continued)

MEASURE HEAT LOSS AND GAIN

SAMPLE FORMAT

1. Determine R-Values and U-Values for the building components.

	R	V
Wall	______	______
Ceilings	______	______
Floors	______	______
Windows	______	______
Doors	______	______

2. Determine areas of building components.

Ext. Walls ______ ft^2
Ceilings ______ ft^2
Windows ______ ft^2
Floors ______ ft^2
Doors ______ ft^2

3. Determine ΔT.

Temperature inside ______ °F
Design Temperature outside ______ °F
T ______ °F

4. Calculate heat flow by conduction (Qc)

Walls ______ BTU/HR
Ceilings ______ BTU/HR
Floors ______ BTU/HR
Windows ______ BTU/HR
Doors ______ BTU/HR

5. Determine heat flow by infiltration (Qi).

$qi = .018 \times Qi \times \Delta T$

6. Calculate Total Heat Flow From Building

Qc = ______ BTU/HR
Qi = ______ BTU/HR
Q Total = ______ BTU/HR

POST-CHECK (Continued)

MEASURE HEAT LOSS AND GAIN

7. Estimate Seasonal Heating Load.

Qs = ______________ BTU/Season

NOTE: Use a similar sample format to estimate cooling load calculations.

POST-CHECK KEY

MEASURE HEAT LOSS AND GAIN

Instantaneous Heat Loss	11,917 BTU/Hr
Seasonal Heat Loss	28,600,800 BTU/Season

MODULE TWELVE

CALCULATING ELECTRICAL ENERGY USAGE (AUDIT) FOR A TYPICAL RESIDENCE

Prepared

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June 1981, R.E. Wenig, Director

CALCULATING ELECTRICAL ENERGY USAGE
(AUDIT) FOR A TYPICAL RESIDENCE

TERMINAL PERFORMANCE OBJECTIVE

This electrical energy audit (usage) module is designed to provide the learning experiences necessary for conducting an electrical usage audit for a typical residence.

Achievement of the terminal performance objective will be accomplished by successfully completing three instructinal packages (IP). Prior to satisfying the IP's requirements, a pre-check evaluation will be required to determine the individual's technical competency level. The results of this pre-check may be used to diagnose and prescribe the IP's that are required to complete this instructional module. Individuals unfamiliar with technical data of this module should eliminate the pre-check and begin the first IP. Those who take the pre-check will record the results below.

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1.	Inventorying electrical consuming devices and manufacturer's data plate information	____	____
IP-2.	Electrical Formula Review	____	____
IP-3.	Calculating power consumption	____	____

PRE-CHECK

CALCULATING AN ELECTRICAL ENERGY USAGE (AUDIT) FOR A TYPICAL RESIDENCE

DIRECTIONS: Place the correct answer on the line adjacent to the question number. Upon completion of the pre-check evaluation, check the answers with the instructor. If any question per IP is missed, it will be necessary to complete the entire module. Record the IP results on page 1.

IP-1. Inventorying Electrical Consuming Devices and Manufacturer's Data Plate Information Collection

_____ 1. Various forms of converted energy are:
- a. light, heat, radiation
- b. work, noise, light, sound
- c. light, heat, radiation, motion
- d. radiation, sound, work, light

_____ 2. List five pieces of technical data found on the manufacturer's data plate:
- a.
- b.
- c.
- d.
- e.

_____ 3. A refrigerator converts electrical energy into which form of energy:
- a. light
- b. heat
- c. radiation
- d. none of the above

_____ 4. What does the E.E.R. number found on electrical consuming device data information plate refer to:
- a. light and heat energy
- b. motion and heat energy
- c. radiation and motion energy
- d. heat and light energy

_____ 5. A microwave oven primarily produces:
- a. light and heat energy
- b. motion and heat energy
- c. radiation and motion energy
- d. heat and light energy

CALCULATING AN ELECTRICAL ENERGY USAGE
(AUDIT) FOR A TYPICAL RESIDENCE

IP-2. Electrical Formula Review

_____ 1. When given the voltage and resistance parameters of an electrical consuming device which power formula is appropriate to use?

a. $P = \frac{1^2}{R}$

b. $P = \frac{R}{1^2}$

c. $P = E \times 1$

d. $P = 1^2R$

_____ 2. An electric toaster when connected to a 120 volt source draws 4 amps. of current. What its internal resistance?

a. 30 ohms
b. 300 ohms
c. 512 ohms
d. 51.2 ohms

_____ 3. What is the voltage drop across a lamp that has an internal R of 60 ohm and draws 2 amps. of I?

a. 30 volts
b. 120 volts
c. 60 volts
d. 12.0 volts

_____ 4. How much current flows through a soldering iron that has an internal R of 120 ohm when connected to a 120V. power source?

a. .1 amp.
b. .01 amp.
c. 1 amp.
d. 10 amp.

_____ 5. What is the EER number for an electrical unit that has a cooling capacity of 5000 BTU. the voltage rating is 115 volts and draws 6.7 amps.

a. 43.47
b. 5.79
c. 746.26
d. 57.9

CALCULATING AN ELECTRICAL ENERGY USAGE

(AUDIT) FOR A TYPICAL RESIDENCE

IP-3. Calculating Power Consumption

_____ 1. An ice cream maker manufacturer's data plate contain the following information technical terms explain what information each item conveys:

a. 120V
b. 60 cps
c. 1.2 amp
d. AC only

household use only

_____ 2. Calculate the total kilowatt hours used in the following problem. All equipment operates on 120 VAC supply.

a. 1200 watts toaster operated for 6 min. on day 1, 20 min. on day 2 and an average of 15 min./day for day 3,4 and 5.

b. An electric range uses 3000 watts for 45 min. on day 1, 2500 for 30 min. on day 2, 4000 watts for 1 hour on day 3, 3500 watts for 1.4 hours on day 4, and 2500 watts for 2 hours on day 5.

PRE-CHECK KEY

CALCULATING AN ELECTRICAL ENERGY USAGE (AUDIT) FOR A TYPICAL RESIDENCE

IP-1. Inventorying Electrical Consuming Devices and Manufacturer's Data Plate Information Collection

1. C
2. A. voltage requirement
   B. current drain
   C. serial number
   D. model number
   E. underwriter's approval
   F. EER

3. D
4. Energy efficiency ratio (EER), expressed in BTU's per watthour, is quotient of the cooling capacity the unit in BTU's per hour divided by its electrical input power in watts.
5. C

IP-2. Electrical Formula Review

1. D
2. A
3. B
4. C
5. B

IP-3. Calculating Power Consumption

1. Test item
   A. voltage supply should be 120 V
   B. use a voltage that has a frequency of 60 Hertzs
   C. current drain 1.2 amps.
   D. use only 60 Hertz AC
   E. underwriter's approved for household use only

2. A. 2.49 Kilowatt hours
   B. 17.3 Kilowatt hours

CALCULATING ELECTRICAL ENERGY USAGE

(AUDIT) FOR A TYPICAL RESIDENCE

IP-1. Inventorying Electrical Consuming Devices and Recording Manufacturer's Data Plate Information

OBJECTIVES

The instructional objective of IP-1 is to provide the learner with an opportunity to:

A. Develop an operational definition for each energy category.

B. Inventory home (including garage and workshop equipment) electrical consuming devices.

C. Interpret the manufacturer's data plate information.

RESOURCES

Books:

1981 Directory of Certified Room Air Conditioners by The Association of Home Appliance Manufacturers, 1981, C3, 4 and 5.

Home Energy Conservation Primer by Michael Vogel, West Virginia University, 1979, p. 24.

Physics by Irwin Guenler, Silver Burnett Co. 1969, Chapters 4, 12 and 13.

National Electrical Code by National Fire Protection Association, 1981.

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ACTIVITY

A. Develop an operational definition for:

Light, motion and radiation

B. Inventory the electrical consuming devices in a home/small building and record the manufacturer's name plate data on Chart, 1-5.

  A. Information accumulated in Chart 1 exceeds that required for completing an energy audit, however this additional data will be useful for maintaining an inventory list and operational condition of the equipment. In addition, it contains the basis for evaluating circuit load distribution. This activity will be accomplished in the module entitled "Energy Used in Small Buildings and Homes."

FEEDBACK

Objective A-C Check:

1. List five pieces of information found on the manufacturer's data plate:
   A.
   B.
   C.
   D.
   E.

2. What is the purpose of the manufacturer's data plate information?

3. Restate the enabling objectives in operational form.

A. Energy that is required to raise the temperature of a specific mass

B. Energy that produces a visual wavelength

C. Energy that produces rotation, expansion, contraction or other forms of movement.

D. Energy that produces magnetic or electric fields.

CALCULATING AN ELECTRICAL ENERGY USAGE
(AUDIT) FOR A TYPICAL RESIDENCE

IP-2. Electrical Formula Review

OBJECTIVES

The objective of IP-2 is a mathematical review of electrical problem solving associated with power consumption. When completing this activity the learner will be able to:

A. Solve ohm law problems with interaction between voltage, current and resistance.

B. Solve electrical power related problems.

C. Develop the relationship between the watt and watt hour.

RESOURCES

Books:

Physics by Irwin Genzer, Silver Burdell Co., 1969, Chapters 10 and 16.

Understanding Electricity and Electronics by Peter Buban and Marshall Schmitt, McGraw-Hill Company, 1975, Chapters 6,7,8 and 9.

ACTIVITY

A. Review the reference material that embraces electrical problem solving.

B. Complete the following ohm's law formula:

1. R = _____

2. I = _____

3. E = _____

C. List the three(3) power formulas:

1. P = _____

2. P = _____

3. P = _____

D. Explain the process for changing watts to watt hours:

E. What formula will convert watt hours to kilowatt hours.

F. Solve the following problems. State the formula to be used and show all work.

1. A 10 ohm heating element when connected to a 240 VAC source will draw how many amperes of current.

2. What is the hot resistance of a lamp that draws 4 amperes of current when connected to 120 VAC?

3. The voltage required to operate a hair dryer with an internal R of 12 ohms drawing 10 amperes.

4. Find the power consumed in Problems a,b and c. Use only the data presented in each problem.

   a. Problem "A"

FEEDBACK

Objective A-C Check:

1. Check the solution to problems A through I with the instructor. Obtain additional review problems for those missed.

2. Restate the enabling objectives, in operational form.

____
Instructor's Approval
IP-2. grade __________

ACTIVITY cont.

b. Problem "B"

c. Problem "C"

5. How many watt hours of power are consumed by the heating element in problem "A" when voltage is applied for 10 hours?

6. The lamp in problem "B" is allowed to burn for 24 hours. How many watt hours of power are consumed?

7. Assume that the hair dryer is used intermittently during a 24 hour period for a total of 6 hours. How many watt hours are consumed?

8. When all of the three devices are simultaneously used, what is the total power consumption?

9. Complete the following chart. Data previously calculated should be used.

Device	E	R	I	P	hours of operation	watt hours	kilo watt hours
Heating Element							
Lamp							
Hair Dryer							
Totals							

FEEDBACK

B. 1. $R = \frac{E}{I}$

2. $I = \frac{E}{R}$

3. $E = I \times R$

C. 1. $P = E \times I$

2. $P = I^2 R$

3. $P = \frac{E^2}{R}$

D. Multiply the number of watt X the time in hours used for each device. Then add the watt hours of each device to obtain total watt hours.

E. Divide the total watt hours by 1000
$$\text{Kilowatt hours} = \frac{\text{total watt hours}}{1000}$$

F. 1. 24a

2. 300 ohms

3. 120 volts

4. a. 5760 watts
   b. 480 watts
   c. 1200 watts

5. 57600 wh

6. 11520 wh

7. 7200 wh

8. 76320 watts

9.

Device	E	R	I	P	hours used	watt hours	kilowatt hours
Heating device	240	10	24	5760	10	57600	57.6
Lamp	120	30	4	480	24	11520	11.520
Hair Dryer	120	12	10	1200	6	7200	72.
Total	XXX	XX	34	7440	XX	76,320	76.320

CALCULATING ELECTRICAL ENERGY USAGE

(AUDIT) FOR A TYPICAL RESIDENCE

IP-3. Calculating Power Consumption:

OBJECTIVES

The instructional objectives of IP-3 are designed to provide the learner with an opportunity to develop learning skills in:

A. Categorizing electrical devices according to their energy producing capabilities.

B. Calculating the energy or power requirement for the inventory list.

C. Estimating the monthly energy consumption.

D. Evaluating the relationship that exists between the estimated and measured power consumed.

NOTE: It will be necessary to measure the kilowatts used for one month to complete this table.

RESOURCES

Books:

Electrical Circuit Actions by Henry Veatch, Science Research Assoc., Inc., 1978, pp. 437-438.

Physics by Irwin Genzer, Silver Burdett Company, 1969, pp. 306-308, 430-435-47.

ACTIVITY

A. Transfer from Chart 1 to Chart 2 the technical data necessary to compute the unknowns presented in Chart 2.

B. Calculate the unknown power requirements for each device.

C. Estimate the daily and monthly power consumption for each device.

D. Determine the degree of need for each electrical device in relationship to effective household operation. Use a realistic approach in this assessment, to avoid personal prejudices. They influence rational judgment. Devices necessary for physical maintenance (i.e., hair dryer, roto hoe) code number 2, luxury items (i.e., television, projector) code number 3 and last, code 4 unnecessary items (i.e., bug killer, dry cell charger).

E. Measure the amount of electrical energy consumed for one month. Compare the relationship that **exist** between the estimated and consumed amounts. Discussion will be required in Step F4 of this unit.

F. Follow the procedure outlined in Steps 1-5 above for completing Charts 3, 4 and 5.

G. Transfer from Charts 2,3,4 and 5 the data necessary to complete Chart 6.

H. Complete chart on demands as illustrated in item IP-2, Activity F-9.

FEEDBACK

1. List three reasons why knowledge of electrical problem solving is necessary when conducting electrical energy audit.
   a.

   b.

   c.

2. Analyze the relationship that **exists** between the estimated and consumed energy. If a dispersion of plus or minus 5 percent between the estimated and actual consumption exists **present reasons for the variations.**

3. What percentage of the estimated energy consumed **is** dispersed among the various need categoried.

   a. Necessary ________________%

   b. Convenience ________________%

   c. Luxury ________________%

   d. Not necessary ________________%

   e. Total ________________%

FEEDBACK cont.

4. Write a detailed analysis of the data compiled in this IP as it relates to household electrical consumption. Emphasis should encompass those concerns for non-essential consumption of electrical energy and subsequential effects in living standard when their absence is encountered. In summarizing this research, don't fail to evaluate the equipment's operational condition and the economics of replacing poor energy efficient units.

Instructor's Approval

IP Grade ____________

POST-CHECK

CALCULATING ELECTRICAL ENERGY USAGE (AUDIT) FOR A TYPICAL RESIDENCE

DIRECTIONS:

Upon completion of the post-check evaluation, the instructor in consultation with the learner will determine the degree of competency achieved. Discrepancies that would hinder the learner's ability to achieve with a certain degree of success those applied activities set forth in this module will be required to perform additional learning activities.

POST-CHECK PROBLEM

1. The following electrical information was taken from a heat-cooling unit.

   1 Phase 208V

   Cooling BTU 12000 BTU Heating cap. 9400 BTU

   Motor Fan 1/6 hp.

a. Calculate the kilowatt hours used when the cooling compressor runs 80% of the time during a 3-day period and the fan motor runs continuously during the same period.

b. Calculate the kilowatt hours used when the heater unit is on 70% of the time during a 3-day period and the fan motor runs 85% of the time during this period.

2. For each form of energy list three pieces of electrical equipment for each category.

   a. Energy form ______

   b. Electrical equipment
      1.
      2.
      3.

   c. Energy form ______

   d. Electrical equipment
      1.
      2.
      3.

   e. Energy form _______

   f. Electrical equipment
      1.
      2.
      3.

g. Energy form ________

h. Electrical equipment
   1.
   2.
   3.

POST-CHECK KEY

1a. 1455 kwh
 b. 1062 kwh

2a. Heat
 b. typical examples
    1. space heater
    2. soldering iron
    3. slowfood cooker

c. motion

d. typical examples
    1. table saw motor
    2. Hi Fi equipment output
    3. Sump pump motor

e. light

f. typical example
    1. light bolt
    2. picture of TV set
    3. projector

g. Radiation
    1. microwave oven
    2. radio transmitter
    3. X-Ray

MODULE THIRTEEN

DESIGN CRITERIA FOR PASSIVE SOLAR ENERGY EFFICIENT RESIDENTIAL CONSTRUCTION

Prepared

by

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USDOE Sponsored Faculty Development Workshop on Energy
Conservation for IAE at North Carolina State University
June 1981 - R.E. Wenig, Director

DESIGN CRITERIA FOR PASSIVE SOLAR ENERGY EFFICIENT RESIDENTIAL CONSTRUCTION

Passive solar designed homes can provide exceptional energy saving and comfort. Following the considerations presented in this module will allow the architect, builders, and home owner factors to use in achieving the best design.

TERMINAL PERFORMANCE OBJECTIVE

At the conclusion of this module the student will be able to prepare a list of design criteria to be considered or employed in an energy efficient residence which utilizes passive solar/thermal mass construction techniques.

As a result of earlier study or practical experience, you may already have a good understanding of energy efficient design techniques. You may wish to take the pre-check to determine the extent of your knowledge on this topic. More than one incorrect response in any section of the pre-check will require completion of the appropriate instructional package.

A final grade of 90% is required on the Post-Check to demonstrate an acceptable knowledge of this topic.

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1	Building Site as a Design Consideration for Passive Solar Homes	____	____
IP-2	Shape and General Design Consideration of an Energy Efficient Passive Solar Home	____	____
IP-3	Construction Details of a Passive Solar Home	____	____

PRE-CHECK

DESIGN CRITERIA FOR PASSIVE SOLAR ENERGY EFFICIENT RESIDENTIAL CONSTRUCTION

Directions: This pre-check is in three sections. More than one incorrect response in any section suggests an unsatisfactory understanding of that sub-topic and will require the student to pursue study of the appropriate instructional package(s) and successful completion of the post-check.

IP-1. Building Site as a Design Consideration for Passive Solar Homes

_____1. Site selection is the first and often most important consideration for any energy efficient building. Generally, a passive solar residence should be located to receive direct sun in the winter from:

A. 7 a.m. to 5 p.m.
B. 9 a.m. to 3 p.m.
C. 6 a.m. to 4 p.m.
D. 8 a.m. to 5 p.m.

_____2. Most experts agree that a building site should be ideally located on a

A. flat lot
B. north sloping lot
C. south sloping lot
D. west sloping lot

_____3. A building site with natural trees can be helpful if:

A. None of the trees are too tall
B. Evergreens are to the north side and deciduous to the south C.
Evergreens are on all sides
D. Deciduous are on all sides

_____4. Climate is a major factor in site selection. The major climate zones in the United States are generally recognized to be:

A. Cold, temperate, hot-humid, hot-arid
B. Cold, temperate, tropical
C. Frigid, temperate, sub-tropic, tropical
D. Northern and southern zones

IP-2. Shape and General Design Consideration of an Energy Efficient Passive Solar Home

_____1. Generally, experts agree that a well designed passive solar building will be:

A. As close to square as possible
B. Square with maximum glass to the south
C. Elongated N-S orientation
D. Elongated E-W orientation

PRE-CHECK (Continued)

DESIGN CRITERIA FOR PASSIVE SOLAR ENERGY EFFICIENT RESIDENTIAL CONSTRUCTION

_____2. Buildings with shapes which disregard the impact of the sun may require:

A. Excessive amounts of energy to heat
B. Excessive amounts of energy to cool
C. Both A and B
D. None of the above

_____3. Traffic patterns in a residence should be carefully planned for a maximum hall space, not to exceed _____ of the total area of the house:

A. 10%
B. 15%
C. 17%
D. 4%

_____4. Generally, rambling structures are being replaced with:

A. Cubical buildings with a maximum surface area and minimum roof area
B. Cubical buildings with a minimum surface and roof area
C. Dome buildings
D. Saltbox designs

IP-3. Construction Details of a Passive Solar Home

_____1. A thermal mass such as a masonry wall or floor can be very effective in:

A. Storing heat
B. Storing cold
C. Both A and B
D. Blocking out cold winter winds

_____2. The sizing of an interior thermal mass wall is critical to insure it is:

A. Not too large for the interior room area
B. Not too large for the amount of south wall glass area
C. Both A and B
D. None of the above

_____3. Entry air locks are proven effective in preventing heat (or cold) from escaping from a building by as much as:

A. 5%
B. 3%
C. 10%
D. 18%

PRE-CHECK (Continued)

DESIGN CRITERIA FOR PASSIVE SOLAR ENERGY EFFICIENT RESIDENTIAL CONSTRUCTION

____4. The minimum recommended side wall insulation in new residence construction in a "cold" climate is:

A. R30 C. R11
B. R9 D. R19

____5. New house construction should have:

A. Double pane insulated glass windows C. Vapor barriers
B. Weatherstripping on all doors D. All of the above

PRE-CHECK KEY

DESIGN CRITERIA FOR PASSIVE SOLAR ENERGY EFFICIENT RESIDENTIAL CONSTRUCTION

IP-1. Building Site as a Design Consideration for Passive Solar Homes

1.
2.
3.
4.
5.

IP-2. Shape and General Design Consideration of an Energy Efficient Passive Solar Home

1.
2.
3.
4.
5.

IP-3. Construction Details of a Passive Solar Home

1.
2.
3.
4.
5.

DESIGN CRITERIA FOR PASSIVE SOLAR ENERGY EFFICIENT RESIDENTIAL CONSTRUCTION

IP-1. Building Site as a Design Consideration for Passive Solar Homes

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. List at least four (4) important considerations for a building site for an energy efficient passive solar home.

B. Prepare a simple technical sketch, to scale, which will demonstrate the considerations in "A" above.

One of the first building design considerations for an energy efficient passive solar home is the building site.

RESOURCES

Books:

The Passive Solar Energy Book. Mazria, E. Rodale Press, Emmaus, PA: 1979, pp. 73.

Architectural Drafting and Design. Weidhass. Boston, MA: Allyn and Bacon, 1978.

Design and Construction Handbook for Energy Saving Homes. Wade, Alex. Emmaus, PA: 1980, pp. 20.

Pamphlet:

DOE/IR/0605-1 Part I
Providing for Energy Efficiency in Homes and Small Buildings. June 1980, pp. 56-58.

Film:

The Solar Builders - and/or Solar Design. Free from National Solar Heating and Cooling Information Center, P.O. Box 1607, Rockville, MD 20850.

ACTIVITY

A. Utilize one or more of the resources on the preceding page as may be necessary.

B. Attend a lecture on the topic of solar home orientation. Use information sheets from reference pamphlet Part I, pages 49-56.

C. Sketch in pencil a simple building lot with a residence located appropriately on the lot. This exercise may be real or hypothetical. Use an 8 1/2 x 11" piece of bond paper with a light 1/4" grid. Select an appropriate scale. Show the direction of the slope of the lot, N-S orientation, shape of the building foundation, landscaping features, and approximate lot and building dimensions.

FEEDBACK

Objective A Check:

1. As soon as you have completed the "B" activity, meet with your instructor to discuss any questions you may have relative to the topic.

Objecitve B Check:

2. Have your instructor check your sketch activity "C" as soon as it is complete.

____
Instructor's Approval

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DESIGN CRITERIA FOR PASSIVE SOLAR ENERGY EFFICIENT RESIDENTIAL CONSTRUCTION

IP-2. Shape and General Design Considerations of an Energy Efficient Passive Solar Home

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Prepare a comprehensive listing of at least six (6) important building shape-general design criteria.

B. Prepare a simple sketch demonstrating as many of these principles as possible.

The building shape and general design of an energy efficient passive solar home is of course very critical if it is to function as desired.

RESOURCES

Books:

The Passive Solar Energy Book. Mazria, E. Emmaus, PA: Rodale Press, 1979. p. 79-83.

From the Ground Up. Cole and Wing. Boston: Atlantic, Little, Brown Pub., 1976, p. 13-48.

Solar Dwelling Design Concepts. AIA Research Corp. Supt. of Documents, St. #023-000-00334-1, 1976.

Pamphlet:

DOE/IR/07065-1 Part I. Providing for Energy Efficiency in Homes and Small Buildings, June 1980, p. 56-65.

Slides:

Passive Solar Slide Show w/ Audio Cassette by Total Environmental Action, Inc., Church Hill, Harrisville, NH 03450.

ACTIVITY

A. Utilize one or more of the resources identified on the preceding page as may be necessary.

B. Attend a lecture on the topic of building shape and general design for passive solar homes. Use information sheet, reference pamphlet Part 1, pages 58-60.

C. Identify a local contractor who has had considerable experience in building this type of home. Contact this person and arrange to visit one or more of the homes he has built which are good examples of passive solar design.

D. Contact another source such as the local Audubon Society, an architect, local power and light company, or gas company to learn what resources they may have to assist you in locating other examples of good passive solar homes which you may visit and/or learn about with respect to floor plans and general shape.

E. Sketch on 8 1/2 x 11" bond paper a simple floor plan of a passive solar residence you have visited or designed. Use a separate sheet for each floor and a separate sheet for the front and one side elevation. Select a suitable scale and provide dimensions for the outside total size and individual home sizes. Keep the major living areas to the south side of the building w/utility areas and bedrooms to the back. The maximum hall area should not exceed 10% of the total building. Incorporate an entry airlock, no windows on the north wall, at least 6" wall thickness w/8" on the north wall preferred.

FEEDBACK

Objective A Check:

1. Meet with the instructor of the lecture you attend in part "B" of activities as soon after the presentation as possible to resolve any questions you may have regarding that lecture.

Objective B Check:

1. Have your instructor check your sketches and discuss them with you as soon after they have been completed as is reasonable.

2. It may be advisable to discuss your sketches with the builder you contacted in activity "C" to benefit from that person's specific ideas.

____

Instructor's Approval

DESIGN CRITERIA FOR PASSIVE SOLAR ENERGY EFFICIENT RESIDENTIAL CONSTRUCTION

IP-3. Construction Details of a Passive Solar Home

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. List at least ten (10) major factors which should be considered and likely employed in any passive solar/thermal mass homes.

B. Explain the pros and cons of utilizing the concepts, techniques, or materials identified in "A" above.

C. Prepare cost factors for each item in "A" above to show the approximate payback period for each.

There are many specific and important construction details to be carefully considered in passive solar/thermal mass homes.

RESOURCES

See resources listed in IP-1 and IP-2 as well as the following:

Books:

From the Walls. Wing, C. Boston, MA: Atlantic, Little, Brown, Co., 1979.

Designing and Building a Solar House. Watson, D. Charlotte, VT: Gardenway Pub. Co., 1977.

Pamphlets:

Technical Booklet-Insulation. Owens/Corning Fiberglass #7.14/ow.

Insulation Guide for Homes and Apartments. Carolina Power and Light Co., Raleigh, NC, 1979.

Energy Savings-Do It With Windows-Heat Pumps-Weather Proofing. A Technical Series from NC Energy Div., P.O. Box 25249, Raleigh, NC 27611.

Solar Fact Sheets. Passive Solar Heating-Cooling, Storing Solar Heat - Windows and Energy Conservation From: US Dept. HUD, Wash. DC 20025.

Window Quilts. Appropriate Technology Corp., P.O. Box 975, Battleboro, VT 05302.

DOE/IR/06065-1 Part I. Providing for Energy Efficiency in Homes and Small Buildings. June 1980, pp. 60-71.

ACTIVITY

A. Attend one or more lectures or Construction Details for Passive Solar/ Thermal mass homes. Use information sheet reference DOE Pamphlet, Part I, pages 60-71.

B. Visit experts who sell, install, and service products (building materials and related items) which would likely be incorporated into a passive solar/ thermal mass home. Specifically, obtain literature and a working knowledge of at least one of the following items:

1. Insulated doors and windows
2. Thermal floor and wall materials
3. Greenhouses
4. Insulation (consider several types including fiberglass, cellulose, styrofoam, ureaformaldehyde, etc.)
5. Heat pumps
6. Wood/coal burning stoves (air-tight variety)
7. Low water - no water toilets
8. Low volume shower - faucet heads
9. Window shutters - thermal blankets (quilts), etc.
10. Timers for water heaters
11. Timers for heating-air conditioning systems
12. Automatic thermostat setbacks
13. Paddle fans
14. Location - gas water heaters
15. Vapor barriers
16. Landscaping for energy savings
17. Pilotless gas heaters - stoves - water heaters
18. Weather stripping - caulking

C. Carefully consider the cost effectiveness of all the items in "B" above that you would use in a passive solar home of your own. Prepare a simple chart showing the approximate payback period for each of these items.

D. For each of the items in "B" above prepare a list of those items you would definitely use in a new passive solar home of your own. For each item you select, give a source to purchase it and a cost of the items installed. If it is possible to purchase and install the item yourself, give the cost of the unit only.

E. Prepare a list of any other energy efficient cost effective items you believe to be appropriate for a passive solar/thermal mass home. For each item give a resource and approximate cost, if known.

FEEDBACK

Objective A Check:

1. As soon after attending the lecture (in Activity A) meet with the instructor to clarify any question you may have relative to the material presented and the topic in general.

Objective B Check:

1. Check with your instructor in locating experts who have products or services of an energy efficient nature.

Objective C. Check:

1. When you have completed the lists in Activities C, D, and E, present them to your instructor for comment and evaluation.

Instructor's Approval

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POST-CHECK

DESIGN CRITERIA FOR PASSIVE SOLAR ENERGY EFFICIENT RESIDENTIAL CONSTRUCTION

Directions: Respond to these questions by selecting the most correct answer. Place your answer on the line immediately to the left of the question.

_____1. The heat loss of a house is directly proportional to:

A. The number of people who generaly live on the second floor
B. The exterior surface area
C. The color of the roof shingles
D. The ratio of 1:5

_____2. The "R" value of a building material is the measure of the:

A. Resistance to heat flow through it
B. Resistance to cold flow through it
C. Both A and B
D. "Rating" of thermal conductivity

_____3. It would be common to have _____ air changes per hour in an energy efficient house:

A. 4-6
B. 3-5
C. 1-2
D. 0.1 to 0.3

_____4. Generally, a passive solar home would have no windows or doors on the:

A. N-E side
B. N side
C. N-W side
D. S-E side

_____5. Solar gain is:

A. Available only in the summer
B. Available only on bright sunny days
C. Heat from the sun
D. Available only when the house faces magnetic south

_____6. An example of thermal mass would be:

A. Any masonry, stone, brick, water, slate, etc. surface which would receive and retain solar gain
B. Any glass surface
C. Any roof surface
D. None of the above

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DESIGN CRITERIA FOR PASSIVE SOLAR ENERGY EFFICIENT RESIDENTIAL CONSTRUCTION

_____7. The orientation of a home on a building lot is critical for a passive solar home. Probably the most important factor of orientation is to have:

A. The building on a slightly sloping lot facing south
B. Town water and sewage
C. Berming
D. Tall trees in front

_____8. Generally, experts agree that triple pane glass is:

A. Advisable in most situations
B. Useful on the south wall
C. Always cost effective on north walls
D. Rarely cost effective

_____9. A greenhouse is capable of providing:

A. Comfortable living space
B. Additional heat in winter
C. A place to grow North Carolina yams
D. All of the above

_____10. A simple "plot plan" should provide:

A. N-S orientation reference
B. Location of building(s) on lot
C. Important dimensions of
D. All of the above

_____11. Vapor barriers are commonly of:

A. 10 mil polyethylene
B. 4-6 mil polyethylene
C. 1-2 Mil kraft paper
D. Foil faced R30 insulation

_____12. When selecting a furnace for forced warm air:

A. Select a slightly oversized furnace
B. Select a slightly smaller capacity furnace than design load
C. Select the same size as design load
D. Always add a heat pump

POST-CHECK (continued)

DESIGN CRITERIA FOR PASSIVE SOLAR ENERGY EFFICIENT RESIDENTIAL CONSTRUCTION

____13. Automatic setback thermostats:

A. Should be used with heating systems
B. Should be used with cooling systems
C. Both A and B
D. Are not cost effective

____14. Wood stoves are frequently a good source of additional heat in a passive solar home. Probably the best type to use is:

A. Sheet metal
B. Air tight
C. A barrel type
D. Made of heavy boiler plate

____15. Passive solar homes frequently make use of a longer than usual roof overhang:

A. On the south side
B. On all sides
C. On all but the north side
D. On the north side only

____16. Passive solar homes often need some type of movable insulation for south facing windows for night use. It should be possible to add an "R" value within the range of ____ with one or more off the shelf techniques:

A. 1-3
B. 3-5
C. 8-12
D. 19

____17. Domestic hot water systems are usually a very major energy user. To minimize this energy consumption the builder should seriously consider using:

A. Quick recovery electric hot water heaters
B. Oil fired units
C. "Demand" systems
D. None of the above

____18. Heating and cooling ducts:

A. Should always be insulated
B. Should always be over ceilings
C. Should not need insulation
D. Should be insulated if located outside the heating/cooling envelope

____19. The best type of caulking material for sealing electrical outlets and metal window frames is:

A. Silicone rubber
B. Acrylic latex
C. Butyl rubber
D. Mortar patch

DESIGN CRITERIA FOR PASSIVE SOLAR ENERGY EFFICIENT RESIDENTIAL CONSTRUCTION

____20. In climates where there is a marginal need for air conditioning, a suitable solution may be:

A. More insulation
B. Shade trees on south side
C. Paddle fans
D. Any or all of the above

POST-CHECK KEY

DESIGN CRITERIA FOR PASSIVE SOLAR ENERGY EFFICIENT RESIDENTIAL CONSTRUCTION

1. B
2. A
3. C
4. B
5. C
6. A
7. A
8. D
9. D
10. D
11. B
12. C
13. C
14. B
15. A
16. C
17. C
18. D
19. A
20. D

MODULE FOURTEEN

HOME ENERGY EFFICIENCY SYSTEMS

Prepared

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USDOE Sponsored Faculty Development Workshop on Energy
Conservation for IAE at North Carolina State University
June 1981 - R. E. Wenig, Director

HOME ENERGY EFFICIENCY SYSTEMS

While energy alternatives are being researched, now more than ever, we need to be energy conscious. Energy conservation begins at home and includes the analysis of energy efficient systems. This instructional module will provide you with information pertaining to energy conservation by analyzing energy efficient systems.

TERMINAL PERFORMANCE OBJECTIVE

Upon completion of this module, you will be able to identify, define, and analyze existing energy efficient systems and design an energy efficient home.

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1.	Terminology: Energy Efficiency	____	____
IP-2.	Factors of Ceiling and Attic Efficiency	____	____
IP-3.	Hot Water Systems and Plumbing	____	____
IP-4.	Space Heating and Cooling as Alternative Energy Systems	____	____

PRE-CHECK

HOME ENERGY EFFICIENCY SYSTEMS

Directions: Answer the following questions true or false. Check your answers with the Pre-Check Key. If you successfully answer the questions for each instructional package, you may choose to go to the next package with the instructor's supervision.

IP-1. Terminology: Energy Efficiency

_____1. The Organization of Petroleum Exporting Countries is an organization that aims at developing common oil-marketing policies.

_____2. In a factory, steam needed for industrial processes or space heating is first run through turbines to generate electricity.

_____3. Efficiency is the ratio of useful work to energy input.

_____4. A year's supply of energy for 10 million automobiles is equal to a quad of energy.

_____5. Although a direct solar system, passive solar design is operated by a commitment to operate manual controls.

IP-2. Factors of Ceiling and Attic Efficiency

_____1. All insulation has vapor barriers.

_____2. 10 inches of attic insulation has an R-value of 30.

_____3. As the rest of the attic, attic doors should be insulated.

_____4. The effectiveness of insulation is measured by R-values.

_____5. Batts refer to insulation blankets.

IP-3. Hot Water Systems and Plumbing

_____1. Collector location and pre-heat tank location are included in the physical requirements of the hot H_2O system.

_____2. Types of materials are important factors in considering plumbing fixtures.

_____3. Sewer lines and vents can be either plastic or cast iron.

PRE-CHECK (Continued)

HOME ENERGY EFFICIENCY SYSTEMS

_____4. Approximately 20% of your total fuel bill is accounted for in heating water.

_____5. Your hot H_2O thermostat should be set the same whether or not you have a dishwater.

IP-4. Space Heating and Cooling as Alternative Energy Sources

_____1. Space heating is accomplished by burning fuels in mechanical equipment.

_____2. Most heating systems, despite differences in design, use three types of energy: gas, oil, and electricity.

_____3. Heating consumes about 68% of all energy used in buildings.

_____4. Cooling consumes less than 5% of energy used in homes.

_____5. The two main types of air conditioners are absorption and compressive refrigeration.

PRE-CHECK KEY

HOME ENERGY EFFICIENCY SYSTEMS

IP-1. Terminology: Energy Efficiency

1. T
2. T
3. T
4. T
5. T

IP-2. Ceiling and Attic Efficiency Systems

1. F
2. T
3. T
4. T
5. T

IP-3. Hot H_2O and Plumbing Systems

1. T
2. T
3. T
4. T
5. F

IP-4. Space Heating and Cooling as Alternative Energy Sources

1. T
2. T
3. T
4. T
5. T

HOME ENERGY EFFICIENCY SYSTEMS

IP-1. Terminology: Energy Efficiency

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Define terms associated with energy efficiency.

B. Identify passive solar and active solar design systems.

RESOURCES

Books:

The Solar Home Book, Heating, Cooling, and Designing with the Sun. Anderson, Bruce. Chehsire Books: Harrisville, NH, 1976, Chapter 1.

Energy, Special Report. National Geographic. February 1981.

Building an Energy Efficient Home. North Carolina Community Colleges Program Development, Department of Community Colleges. (Course Outline and Instructional Materials), 1979.

ACTIVITY

Do each one of the activities listed below.

A. Review the resources that are listed.

B. In one or two sentences, define these terms:

1. Efficiency
2. Photovoltaics
3. BTU
4. Renewable Energy Source
5. Quad
6. Cogeneration
7. OPEC
8. Synfuels

C. Compare the answers in activity "B" with the Pre-Check for IP-1.

D. Define passive solar systems and compare them to active solar systems.

E. Read chapters four and six of The Solar Home Book.

FEEDBACK

Answer guide to activities B and D.

Objective A Check:

1. Efficiency - The ratio of useful work or energy output to total work or energy input.
2. Photovoltaics - The process by which radiant energy is converted directly into electrical energy using a solar cell.
3. BTU (British Thermal Unit) - The amount of heat necessary to raise the temperature of one pound of water one degree Farenheit.
4. Renewable Energy Source - One that is constantly or cyclically replenished, including direct solar energy and indirect sources such as bio-mass and wind power.
5. Quad - A quadrillion BTU's. The energy contained in 8 billion gallons of gasoline, a year's supply for 10 million automobiles.
6. Cogeneration - The production of two useful forms of energy from the same process. For example, in a factory steam needed for industrial processes or space heating is first run through turbines to generate electricity.

7. OPEC - The Organization of Petroleum Exporting Companies, 13 nations that aim at developing common oil-marketing processes.

FEEDBACK (Continued)

8. Synfuels - Fuels synthesized from sources other than crude oil or natural gas and used in place of them or their derivatives, primarily for transportation and heating boilers.

Objective B Check:

D. A passive solar system includes a solar heating or cooling system that uses no external mechanical power to move the collected solar heat. It differs from an active system in that an active system requires mechanical power to move the collected heat.

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IP-2. Ceiling and Attic Efficiency Systems

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. List the effects of ventilation in attics.

B. Given the U-value of the material shown in the cross section of a wall, calculate the total R-Value.

RESOURCES

Books:

The Solar Home Book, Heating, Cooling, and Designing With the Sun. Anderson, Bruce and Michael Border. Harrisville, NH: Cheshire Books, 1976.

Pamphlets:

DOE/IR06065-1 Part I, Providing for Energy Efficiency in Homes and Small Buildings. DOE, June 1980, p. 70.

Energy Saving Is Having Insulation. North Carolina Energy Divison, DOE, EPCA, PL94-163.

Al Ubell's Energy Saving Guide for Homeowners. Warner Books, New York, 1980.

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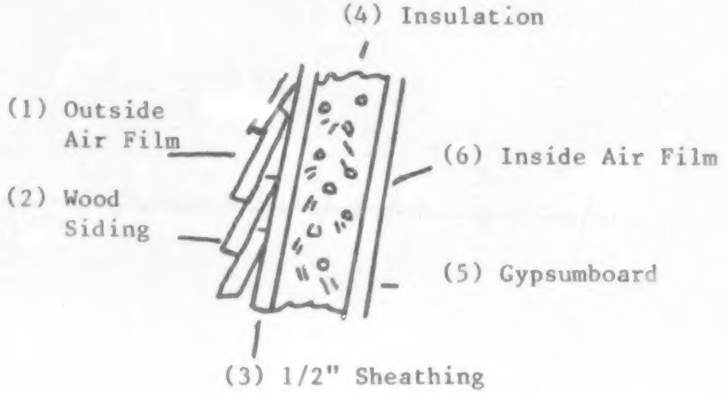
ACTIVITY

A. Study the resources listed concerning ceilings and attic systems.

B. Explain the importance of vapor barriers.

C. Diagram a cross section of an exterior stud-wall to equal an R-value of 11-12.



MATERIALS	U-VALUE
1	5.88
2	1.23
3	.75
4	.09
5	2.22
6	1.47

FEEDBACK

Answers to activities "B" and "C".

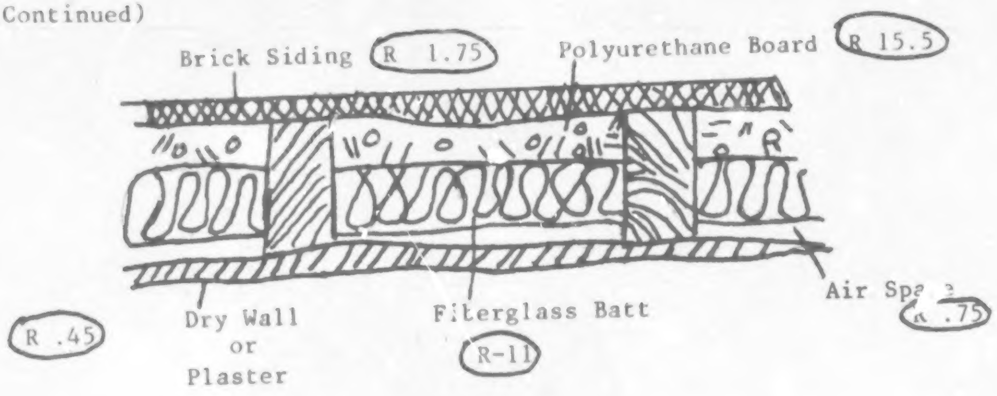
Objective A check:

1. Warm air hold more moisture than cold air. When that warm, moisture-laden air hits the cold surfaces in unheated protions of the attic and walls, dew forms. But if you can place something to stop the moisture between the cold surface and the heated air, dew will not form. Insulation will not do that job by itself. Most insulation materials collect the moisture. So you need to install a vapor barrier between the warm portions of the house and the insulation.

Objective B Check:

1. Compute the total R-value for the following wall section:

FEEDBACK (Continued)


Brick Siding
R 1.75
Polyurethane Board
R 15.5
Air Space
R .75
R .45
Dry Wall
or
Plaster
Fiberglass Batt
R-11

MATERIALS	SIZE	R-VALUES

*Refer to Chart on Page 98 of The Solar Home Book to get R-Values and to Resource Pamphlet DOE IR06065-1 Part II, pages 49-66.

HOME ENERGY EFFICIENCY SYSTEMS

IP-3. Hot Water Systems and Plumbing

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Evaluate existing home systems that are energy efficient.

B. Identify a good home conservation system design.

C. Review activity answers with the IP-3 Pre-Check.

RESOURCES

Books:

The Solar Home Book, Heating, Cooling, and Designing With the Sun. Anderson, Bruce and Michael Border. Harrisville, NH: Cheshire Books, 1976, p. 208.

Pamphlets:

Building an Energy Efficient Home. Dilday and Dixon. Course Outline and Instructional Materials. June 1979, DOE PL-94-163, PL-94-385, EPCA.

Energy: Saving is Having, Hot Water Systems. North Carolina Energy Division, DOE, Energy Policy and Conservation Act, PL-94-163.

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ACTIVITY

A. Review resources.

B. Determine how effective thermostatically controlled hot water heaters are.

C. Defend the necessity of insulating water heaters for efficiency.

D. Determine the approximate percentage of heating hot water on a total energy bill.

E. Investigate household needs of setting the thermostat.

F. Review washerless water tap valves and make a value judgment as to their worth in energy conservation.

FEEDBACK

Answer to activity questions B - F.

Objective A-B Check:

1. A thermostatically controlled hot water heater is a simple device which (1) heats water automatically and (2) stores heated water. In many hot water systems, less than half the energy consumed by the heater actually results in hot water at the tap. Some of the energy is lost as the heated water tank slowly cools off, some of the heat is lost up the flue (in gas heaters), and some of the heat is lost through distribution.

2. By wrapping the outside of your water heater with insulation, you can cut your heat losses by 50% and cut 10% - 20% off water heating costs. It's simple to do and will keep the water hot until it reaches the tap.

3. Approximately 20% of your total fuel bill is for heating hot water.

4. A thermostat setting of 120° is sufficient for most homes without a dishwasher. A setting of 140° is recommended if there is a dishwasher in the home.

5. A washerless valve uses two gem-smooth ceramic discs instead of washers and seats. Washerless faucets eliminate water leakage which can account for 5 - 10% of residential water consumption.

HOME ENERGY EFFICIENCY SYSTEMS

IP-4. Space Heating and Cooling as Alternative Energy Systems

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Research home space heating and cooling to compare with other energy efficient systems.

B. Develop an energy efficient home.

RESOURCES

Books:

Other Homes and Garbage. Leckie, Jim et al. San Francisco: Sierra Club Books, 1975, p. 144-146.

The Solar Age Resource Book, ed. of Solar Age Magazine. New York: Everest House, 1979, p. 135-136, 75-81.

Pamphlets:

Building an Energy Efficient Home. Course Outline and Instructional Materials, North Carolina Department of Community Colleges, Program Development, 1979.

DOE/IR/06065-1 Part I, Providing for Energy Efficiency in Homes and Small Buildings. DOE, June 1980.

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ACTIVITY

A. Study Part I, "Providing for Energy Efficiency in Homes and Small Buildings."

B. Read resources for IP-4.

C. Review all instructional packages and resources.

D. List criteria for developing an energy efficient home system.

FEEDBACK

Objective A-B Check:

1. It is essential to consider the following factors for an energy efficient home system:

   1. Heat
   2. Insulation
   3. Windows and Doors
   4. Water Heating and Usage
   5. Ventilation and Air
   6. Lighting
   7. Types of Insulation
   8. Vapor Barriers
   9. Weatherstripping
   10. Caulking
   11. Landscaping
   12. Roofing and Siding

POST-CHECK

HOME ENERGY EFFICIENCY SYSTEMS

Directions: Provide the appropriate response to each test item that correctly answers/completes the statement.

_____1. The production of two useful forms of energy from the same process is:

A. Renewable energy source
B. Synfuels
C. Cogeneration

_____2. About a quarter of a calorie equals:

A. A quad
B. A BTU

_____3. Active solar systems use no external mechanical power to move collected solar heat.

True
False

_____4. The total U-value of a ceiling is:

A. The R-value of insulation plus siding thickness
B. Printed on all materials that comprise a ceiling
C. Equal to the reciprocal total R-values of all the materials used in the ceiling structure.

_____5. Ventilation is essentially:

A. The controlled intake of fresh air
B. Circulation
C. Exhaust
D. All of the above
E. A and B only

_____6. Name the basic types of ventilation.

_____7. By wrapping the outside of your water heater, you can cut heat losses by:

A. 25%
B. 75%
C. 50%

_____8. Thermostatically controlled hot water heaters:

A. Heat water automatically
B. Store heated water
C. Both A and B

POST-CHECK (Continued)

HOME ENERGY EFFICIENCY SYSTEMS

_____9. Your total fuel bill for hot water is approximately:

A. 15%   B. 35%   C. 20%

____10. Solar collector location and pre-heat tank location are included in the physical requirements of the hot water system.

True   False

____11. If you have a dishwasher, it is more energy efficient to keep your thermostat setting the same as if you did not have a dishwasher.

True   False

____12. Of all energy used in homes, heat consumes about:

A. 50%   B. 35%   C. 75%   D. 68%

____13. The two main types of air conditioners are absorption and compressive refrigeration.

True   False

____14. Name the three types of energy used in most home space heating systems.

____15. List five (5) influencing factors to consider in energy efficiency home construction.

POST-CHECK KEY

HOME ENERGY EFFICIENCY SYSTEMS

1. C
2. B
3. F
4. C
5. E
6. Forced and Natural
7. A
8. C
9. C
10. T
11. T
12. D
13. T
14. Electric, Gas, Oil
15. Site, Insulation, Windows, Trees, Source of Heat, Doors, Ventilation System

MODULE FIFTEEN

ENERGY EFFICIENT MATERIALS PART I:
INSULATION, VAPOR BARRIERS, CAULKING AND WEATHERSTRIPPING

Prepared

by

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USDOE Sponsored Faculty Development Workshop on Energy
Conservation for IAE at North Carolina State University
June 1981-R.E. Wenig, Director

ENERGY EFFICIENT MATERIALS, PART I.

INSULATION, VAPOR BARRIER, CAULKING AND WEATHERSTRIPPING

The home owner who has a sufficient quantity of properly installed insulation realizes two major benefits: greater comfort and less energy consum Insulation is important because it conserves our nation's natural resources and lowers heating and cooling costs. As energy resources continue to diminish, its costs will increase and the savings realized will accumulate.

TERMINAL PERFORMANCE OBJECTIVE

Those who study this module will be able to:

A. Identify the various types of insulation, vapor barriers, weatherstripping and caulking.

B. List factors to be considered in the selection and placement of weatherization materials.

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1.	Types of insulation, vapor barriers, weatherstripping and caulking to use	____	____
IP-2.	How much insulation to use	____	____
IP-3.	How much vapor barrier, weatherstripping and caulking to use	____	____
IP-4.	From a set of house plans tell where to place weatherization materials as shown in IP-1, IP-2 and IP-3.	____	____

PRE-CHECK

ENERGY EFFICIENT MATERIALS, PART I.

INSULATION, VAPOR BARRIER, CAULKING AND WEATHERSTRIPPING

DIRECTIONS: Place a T for all true statements and a F for all false statements. If you miss any question in the various IPs, please complete that instructional package.

IP-1. Types of insulation, vapor barriers, weatherstripping and caulking to use

_____ 1. Fiberglass is fire resistant.

_____ 2. A contractor is not required to install insulation.

_____ 3. Blown insulation is installed under pressure.

_____ 4. Loose fill comes in bags.

_____ 5. Fiberglass is not the most common of all insulators.

_____ 6. Boards are pre-cut to standard size.

IP-2. How much insulation to use

_____ 1. "R" value measures resistance to penetration.

_____ 2. Vapor barriers are applied to the warm side of the insulation.

_____ 3. To determine the area of your floor to be insulated you would multiply the length times the width.

_____ 4. Length times height plus 3' = area is the formula to use when figuring insulation for the crawl space.

IP-3. How much vapor barrier, weatherstripping and caulking to use

_____ 1. Weatherstripping is placed around foundations and cornices.

_____ 2. Caulking is used to smooth joints between bricks.

_____ 3. Caulking comes in tubes.

_____ 4. Urea-formaldehyde foam is pumped into wall cavities.

IP-4. From a set of house plans tell where to place weatherization materials as shown in IP-1, IP-2 and IP-3

_____ 1. There are three types of vapor barriers.

_____ 2. Rock or mineral fiber is much like fiberglass.

_____ 3. Blankets come in rolls.

_____ 4. Boards are pre-cut to standard size.

PRE-CHECK KEY

ENERGY EFFICIENT MATERIALS

INSULATION, VAPOR BARRIER, CAULKING AND WEATHERSTRIPPING

IP-1. Types of Insulation, Vapor Barriers, Weatherstripping and Caulking to Use

1. True
2. True
3. True
4. True
5. False
6. True

IP-2. How Much Insulation to Use

1. True
2. True
3. True
4. True

IP-3. How Much Vapor Barrier, Weatherstripping and Caulking to Use

1. False
2. False
3. True
4. True

IP-4. From a Set of Home Plans Tell Where to Place Weatherization Materials as Shown in IP-1, IP-2 and IP-3

1. True
2. True
3. True
4. True

ENERGY EFFICIENT MATERIALS PART I:

INSULATION, VAPOR BARRIER, CAULKING AND WEATHERSTRIPPING

IP-1. Types of Insulation, Vapor Barriers, Weatherstripping and Caulking to Use

OBJECTIVE

Upon completion of this instructional package, you will be able to:

A. Identify different types of insulation, vapor barriers, weatherstripping and caulking.

B. Figure the "R" value of insulation materials.

RESOURCES

To help you reach your objective, use the following resources:

Books:

In the Bank . . . or Up the Chimney by H.U.D., DOE/IR/06065-1-3.

Providing for Energy Efficiency in Homes and Small Buildings, Part III by U.S. Dept. of Energy, June 1980.

Modern Carpentry by Wagner, Goodheart-Wilcox.

ACTIVITY

Do each of the activities listed below:

A. Compare the insulation qualities of the insulation materials as listed on page 26, Providing for Energy Efficiency in Homes and Small Buildings-Part III by DOE.

B. Figure the "R" value showing the above insulation materials.

C. Make a drawing showing the "R" value of a wall section without insulation.

D. Make a drawing showing the "R" value of a wall section with insulation.

E. List the three different types of vapor barriers.

F. List seven advantages of the different types of weatherstripping as listed on page 37, Providing for Energy Efficiency in Home and Small Buildings-Part III by DOE.

G. List six problems and solutions when using different types of caulking.

FEEDBACK

Objective a Check:

1. Give the "R" value of the materials listed below:

Materials	R-Value Per Inch
Fiberglass	
Rock Wool	
Cellulose Fiber	
Styrofoam	
Urea-Formaldehyde	
Polyurethane	

2. Show your drawing to your instructor.

3. List three types of vapor barriers.

1. ______________ 2. ______________ 3. ______________

4. List seven advantages of the different types of weatherstripping.

1. ________________ 2. ________________ 3. ________________

4. ________________ 5. ________________ 6. ________________

7. ________________

5. List six problems when using different types of caulking.

ENERGY EFFICIENT MATERIALS PART I:

INSULATION, VAPOR BARRIER, CAULKING AND WEATHERSTRIPPING

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Determine how much insulation to use in the critical areas of a house.

RESOURCES

To help you reach your objective, use the following resources:

Books:

Framing Sheathing and Insulation by Delmar Publishers, Inc. ODE/IR/06065-1-2.

Providing for Energy Efficiency in Homes and Small Buildings-Part III by U.S. Dept. of Energy, June 1980.

Modern Carpentry by Wagner, Goodheart-Wilcox.

ACTIVITY

Do each of the activities below by referring to your set of house plans.

A. Accurately determine your attic area. If necessary, divide it into rectangles and sum the areas.

B. How is blown insulation placed in the walls?

C. Determine the amount of insulation required to insulate your crawl space walls using the formula as shown on page 54 of the text.

D. Determine the area of your floor to be insulated by measuring the length and width and multiplying to get the area.

FEEDBACK

Objective A Check:

1. You would determine your attic area by multiplying the length times width.

2. Blown insulation is placed in the walls by boring a hole at the top of the wall.

3. The amount of insulation is determined by the following formula: (Length) x (height + 3') = area

4. Show your calculations to your instructor.

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ENERGY EFFICIENT MATERIALS PART I:

INSULATION, VAPOR BARRIER, CAULKING AND WEATHERSTRIPPING

IP-3. How much Vapor Barrier, Weatherstripping and Caulking to Use

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Identify different types of vapor barriers, weatherstripping and caulking to use.

B. Determine how much weatherization material to use.

RESOURCES

To help you reach your objective, use the following resources:

Books:

Same as IP-1.

Brochure:

Anyone Can Do It: Total Home Weatherproofer's Guide by Macklanburg, Duncan Co.

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ACTIVITY

Do each of the activities listed below:

A. Sketch a typical wall section in isometric showing where the vapor barrier should be placed.

B. Review the information on resource brochure, Anyone can do It: Total Home Weatherproofer's Guide.

C. Make a list of where a house needs to be caulked.

D. Make a list of tools that you would need when caulking your house.

E. List the safety factors you should know when caulking your house.

F. Make a rough estimate of the cartridges of caulking compound required.

G. Make a list of the amount of weatherstripping that you would need for each window and door in your house.

FEEDBACK

Objective A Check:

1. Take a practical and paper pencil test over the resource brochure on Weatherproofing - Percent of infiltration, Problem points, what to do, work needed and solution.

Objective B Check:

1. Show your sketch to your instructor.
2. Show your list to your instructor.
3. Show your list to your instructor.
4. Show your list to your instructor.
5. Show your estimate to your instructor.
6. Show your list to your instructor.

ENERGY EFFICIENT MATERIALS PART I:

INSULATION, VAPOR BARRIER, CAULKING AND WEATHERSTRIPPING

IP-4. From Your Set of House Plans, Place Numbers Where You Would Place Weatherization Materials as Shown in the First Three Instructional Packages

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Install correctly all weatherization material in your house.

RESOURCES

To help you reach your objective, use the following resources:

Books:

Architecture, Drafting and Design by Hepler.

Framing Sheathing and Insulation by Jones.

In the Bank or Up the Chimney by H.U.D.

Providing for Energy Efficiency in Homes and Small Buildings-Part III by U.S. Dept. of Energy, June 1980. DOE/IR/06065-1.

ACTIVITY

A. Study your house plans and make a list of each kind of window.

B. List the kind of weatherization material that you would use on each window.

C. Make a list of the doors and tell what kind of weatherization material you would use.

D. Make a list of the most critical places to caulk.

E. From your plans determine how and where you would insulate your attic.

F. What thickness of insulation would you have put in your exterior walls?

G. Where would you insulate your crawl space or basement?

FEEDBACK

Objective A Check:

1. Show your list to your instructor.
2. Show your list to your instructor.
3. Show your list to your instructor.
4. Show your list to your instructor.
5. Have your instructor check your calculations.
6. You would put 3½" fiberglass in your walls.
7. You would insulate your crawl space from the tops of the header down and two feet out on to the crawl space.

POST-CHECK

ENERGY EFFICIENT MATERIALS PART I.

INSULATION, VAPOR BARRIER, CHAULKING AND WEATHERSTRIPPING

1. Match terms to definitions:

a. BTU	________	1. Rate of heat flow
b. BTU/HR	________	2. Heat flow by solar energy
c. Heat flow by conduction	________	3. Unit of heat
d. Heat flow by infiltration	________	4. Heat flow through solids
e. Heat flow by radiation	________	5. Heat loss through air exchange

2. Match terms to definitions:

a. Thermal conductivity (K value)	________	1. Heat transferred through a material 1 sq. ft., any thickness
b. Thermal conductance (C value)	________	2. Heat transferred through a material 1 sq. ft., 1 ft. thick
c. Coefficient of heat transfer (U value)	________	3. Resistance to heat flow
d. Thermal resistance (R value)	________	4. Heat transferred through a wall section

3. The formula for heat flow by conduction (Q C) through a composite wall is:

   a. 1/R+ (tz - t1) _____

   b. R1 + R2

4. The purpose of insulation is to: _____

   a. increase heat transfer
   b. reduce heat transfer
   c. improve appearance

5. Energy moves from: _____

   a. a high to a low temperature
   b. top to bottom
   c. a low to a high temperature

POST-CHECK

(Continued)

6. Insulation quality is usually based on the amount of: _____

   a. glass
   b. vapor barrier
   c. air space within the insulation

7. "R" value is: _____

   a. the resistance to air flow
   b. the rate of heat transfer
   c. the resistance to energy flow

8. Types of insulation are as follows: _____

   a. Fiberglass
   b. Rock wool
   c. Cellulose
   d. Polyurethane
   e. All of the above

9. Characteristics of insulation to look for are: _____

   a. Fire resistance
   b. R-value
   c. Foam
   d. All of the above

10. Fiberglass comes in: _____
    a. Rolls
    b. Batts
    c. Both

11. Forms of insulation are: _____

    a. Blankets
    b. Batts
    c. Loose-fill
    d. Masonry
    e. All of the above

12. The R value of insulation sheathing per inch thickness is: _____

    a. 10
    b. 6
    c. 2

POST-CHECK

(Continued)

13. Cellulose fiber: _____

    a. is fire resistant
    b. must be treated for fire resistance
    c. comes in batts

14. Three types of vapor barriers are: _____

    a. Polyethylene film
    b. Aluminum foil
    c. Paints
    d. All of the above

15. Polyethylene film is available in thicknesses of: _____

    a. 2-6 mils
    b. 3½ to 4 inches

16. Paints are used as a vapor barrier: _____

    a. in old buildings
    b. in hallways
    c. in new construction

17. Three advantages of caulking and weatherstripping are to: _____

    a. increase the U value of walls
    b. reduce the air exchange
    c. reduce energy use
    d. all of the above

18. Weatherstripping is used on: _____

    a. doors and windows that open and close
    b. cracks around window frames
    c. Soffit vents

19. All caulking is the same: _____

    a. True
    b. False

POST-CHECK

(Continued)

20. Weatherstripping and caulking should be done: _____

    a. as a last resort
    b. frequently

POST-CHECK KEY

1. 1b, 2e, 3a, 4e, 5d
2. 1b, 2a, 3d, 4c
3. a
4. b
5. a
6. c
7. c
8. c
9. d
10. c
11. a b c
12. c
13. b
14. a b c
15. a
16. a
17. b c d
18. a
19. b
20. a

MODULE SIXTEEN

ENERGY EFFICIENT MATERIALS PART II: DOORS, WINDOWS, STORM DOORS AND WINDOWS, FLOORS CEILINGS, ATTICS AND LIGHTING

Prepared

by

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Conservation for IAE at North Carolina State University
June 1981-R.E. Wenig, Director

ENERGY EFFICIENT MATERIALS PART II

DOORS, WINDOWS, STORM DOORS AND WINDOWS, FLOORS CEILINGS, ATTICS AND LIGHTING

The module and related instructional packages were written with the express purpose of making an individual more aware of energy efficient materials. An individual who works through the instructional packages should be able to select components to improve the energy efficiency of existing facilities.

TERMINAL PERFORMANCE OBJECTIVE

After completion of this module the individual should be able to identify the elements that constitute energy efficient materials in doors, windows, storm doors and windows, floors, ceilings, **attics and lighting.**

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1.	Energy Efficiency **of Materials Used in Doors**	____	____
IP-2.	Energy Efficiency of Materials Used in Various Windows	____	____
IP-3.	Energy Efficient Materials for Storm Doors and Windows	____	____
IP-4.	Energy Efficient Materials for Floors	____	____
IP-5.	**Energy Efficient Materials for Ceilings and Attics**	____	____
IP-6.	**Energy Efficient Materials Used in Lighting**	____	____

PRE-CHECK

DOORS, WINDOWS, STORM DOORS AND WINDOWS, FLOORS CEILINGS, ATTICS AND LIGHTING

Achievement of the terminal performance objective may be accomplished by one of the following methods:

a) Taking the pre-test for each of the six instructional packages with a 100% score. This would indicate that you already possess the skills and knowledge contained in this module.

b) Finishing each of the instructional packages and making a satisfactory score on each activity.

c) Completing the post-test or check after completion of the six instructional packages.

DIRECTIONS: Answer the questions for each of the six pre-tests of the instructional packages by circling T for all statements that are true and F for statements that are false. Have your answer sheet checked by your instructor.

IP-1. Energy Efficiency of Materials Used in Doors

T F 1. The solid wooden door has a higher "R" value than the steel clad foam center door.

T F 2. The hollow-core door is not the best exterior door.

T F 3. The "R" value of a steel clad foam center door 2" thick is 5.1.

T F 4. The "R" value of a 1" solid wooden door is approximately 10.94.

IP-2. Energy Efficiency of Materials Used in Various Windows

If you complete the questions below with a 100% score then go to 1P-3 pre-test.

_____ 1. The relationship of an "U" value to a "R" value is:

a) $\frac{U}{R} = 1$ b) $\frac{1}{U} = R$ c) R = 1 x U d) $\frac{U}{I} = R$

_____ 2. A single strength sheet of glass is ______ inch thick.
a) ¼ b) 1/8 c) 3/32 d) 5/32

_____ 3. The "R" value of a double glazed window is greater than that of a single glazed window.
a) True
b) False

PRE-CHECK

(Continued)

_____ 4. A triple glazed window has an "R" value three times as large as the single glazed window.
a) True
b) False

IP-3. Energy Efficient Materials for Storm Doors and Windows

_____ 1. Which of the following combinations has the best "R" factor:
a) ¼" thick single glazed glass
b) double strength double glazed (¼" air space)
c) double strength triple glazed (¼" air space)

_____ 2. Which of the two combinations has the best "R" value:
a) double glass; separated by ¼" air space
b) double glass; separated by ½" space

_____ 3. Wooden storm doors are more effective in reducing heat loss than metal doors.
a) True
b) False

_____ 4. The Solar Transmission "U" value for various thicknesses of glass are: (Match "U" value with glass thickness)

a) ¼"	a) 0.84
b) 1/8"	b) 0.78
c) ½"	c) 0.72
d) 3/8"	d) 0.67

IP-4. Energy Efficient Materials for Floors

_____ 1. Insulation should be installed in floors:
a) exposed to unheated areas only
b) wherever they are found
c) only if they are made of hardwood

_____ 2. Flexible insulation with vapor barrier backing has:
a) the vapor barrier installed toward the ground
b) the vapor barrier installed next to the heated side

_____ 3. What types of insulation are generally used in floors?
a) flexible b) rigid c) reflective d) all of the above

_____ 4. Loose-fill insulation is not generally used in floors.
a) True
b) False

PRE-CHECK

(Continued)

_____ 5. Rigid insulation may be placed around the perimeter of a slab floor.
a) True
b) False

IP-5. Energy Efficient Materials for Ceilings and Attics

_____ 1. Blanket insulation with a paper or vapor barrier (non-foil) backing may be stapled:
a) to the outside of the joist b) to the inside edge of the joist
c) either way

_____ 2. Recessed light fixtures must not be covered with insulation
a) True
b) False

_____ 3. When using loose-fill insulation, vapor barriers are not required
a) True
b) False

_____ 4. Rigid insulation (sheets) is used:
a) where the roof and ceiling are one such as cathedral ceilings
b) between stories

_____ 5. A combination of rigid and flexible insulation may be used in sloped ceilings framed with rafters
a) True
b) False

_____ 6. Vapor barriers should:
a) have holes punched for air circulation
b) have no holes or torn places

_____ 7. Blanket insulation comes in rolls up to 3½" thick and 16" or 24" wide
a) True
b) False

_____ 8. Batts insulation comes in sections up to 6" thick and 16" to 24" wide
a) True
b) False

_____ 9. Insulation should be placed in the following ceilings:
a) all ceilings
b) only ceilings exposed to unheated attics or directly covered by roofs
c) only ceilings directly covered by roofs

PRE-CHECK

(Continued)

_____ 10. Loose-fill insulation may be installed by
a) pouring b) flowing c) either

IP-6. Energy Efficient Materials Used in Lighting

_____ 1. Which is the most energy efficient lighting?
a) natural lighting b) electric lights c) gas lights

_____ 2. The two types of lights are
a) natural b) **artificial**

_____ 3. Which of the artificial lights are the most energy efficient?
a) incandescent b) fluorescent c) high intensity

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PRE-CHECK KEY

ENERGY EFFICIENT MATERIALS PART II

DOORS, WINDOWS, STORM DOORS AND WINDOWS, FLOORS, CEILINGS, ATTICS AND LIGHTING

IP-1. Energy **Efficiency** of Materials Used in Doors

1. False
2. True
3. False
4. False

IP-2. Energy Efficiency of Materials Used in Various Windows

1. B
2. C
3. True
4. False

IP-3. Energy Efficient Materials for Storm Doors and Windows

1. C
2. B
3. A
4. a-b, b-a, c-d, d-c

IP-4. Energy Efficient Materials for Floors

1. A
2. B
3. A
4. A
5. A

IP-5. Energy Efficient Materials for Ceilings and Attics

1. C
2. A
3. B
4. A
5. A
6. B
7. A
8. A
9. A
10. C

PRE-CHECK KEY
(Continued)
ENERGY EFFICIENT MATERIALS PART II

DOORS, WINDOWS, STORM DOORS AND WINDOWS, FLOORS, CEILINGS, ATTICS AND LIGHTING

IP-6. Energy Efficient Materials Used in Lighting

1. A
2. natural-artificial
3. B

ENERGY EFFICIENT MATERIALS PART II

DOORS, WINDOWS, STORM DOORS AND WINDOWS, FLOORS CEILINGS, ATTICS AND LIGHTING

IP-1. Energy Efficient Materials Used in Doors

OBJECTIVE

Upon completion of this instructional package, you will be able to:

A. Name the energy efficient materials that are used in the construction of doors.

RESOURCES

Books:

Concepts in Thermal Comfort by M. David Egan, Englewood Cliffs, N.J.: Prentice Hall, Inc. 1975 p. 63.

Modern Carpentry (Rev. ed) by Willis Wagner, Homewood, Ill: Goodheart Willcox, Inc. 1979 pp (chapter on Doors).

Pamphlets:

Providing for Energy Efficiency in Homes and Small Buildings, Part III, by U.S. Department of Energy, Washington, D.C.: Office of Consumer Affairs, Education Division, 1980 pp. 46-48.

In the Bank or Up the Chimney, by U.S. Government Printing Office, 2nd edition Washington, D.C.: Office of Policy Development and Research, Division of Energy, Building Technology and Standards, U.S. Dept. of Housing and Urban Development, August, 1977 pp. 8, 38.

Information Sheet: for IP-1 (handout)

ACTIVITY

A. Read the references listed above before attempting to do this activity. Upon completion of the reading assignment fill in the chart below for the various sizes of exterior doors.

DOOR TYPES	THICKNESS		"R" VALUES	
	cm	inches	SI	(US)
Solid wooden door	2.5	1"		
Solid wooden door	3.2	1¼"		
Solid wooden door	3.8	1½"		
Solid wooden door	5.1	2"		
Steel clad foam center door	2.5	1"		
Steel clad foam center door	3.8	1½"		
Steel clad foam center door	5.1	2"		

IP-1 Information Sheet

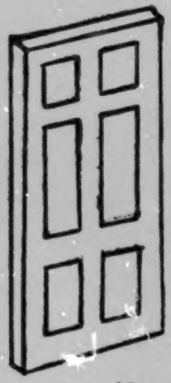
Doors

Exterior doors are constructed of wood, metal or fiberglass. Doors made of wood and metal have been the two common materials for a number of years. Fiberglass is a relatively new material and little technical data is available on it as to its insulation qualities. Doors affect the heat loss or gain by both conduction and air infiltration. A door, when installed properly with weatherstripping and insulation of frame area, has a significant insulating factor.

Solid Wood Doors

Solid wood doors are made of solid planks or frames with panel inserts as a decoration. The insert is often thinner than the frame and causes a reduction in the "R" factor or insulation value (Figure 1).

FIGURE 1



Solid Wooden Door

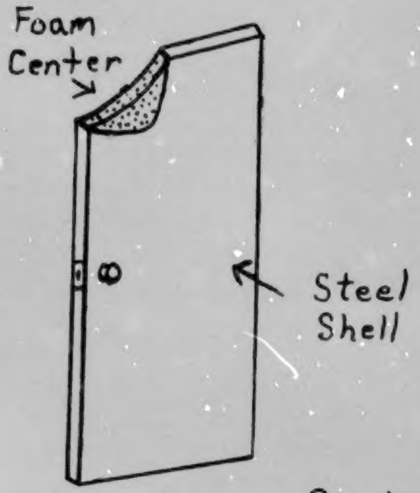
Hollow Core Doors

Hollow core doors' construction consist of a basic frame and inserts where the door handle and hinges will be placed. The hollow-core door is seldom used as an exterior door except where the exit leads into an attached garage where it would not be exposed to the outside elements. The door frame is usually faced on both sides with 1/8" birch or mahogany veneer as the exterior surface skin of the door. Many hollow-core doors have a network of corrugated cardboard set on edge as a stiffener for the door. The "R" values of hollow-core doors are seldom listed since they are not recommended for exterior use.

Steel Clad Foam Core Doors

These doors usually have a wooden frame and wood inserts where the hardware is normally attached to the door. The remainder of the inside of the door is filled with urethane foam. This is the best door for high insulation values. This is the exterior door most often used by modern builders (Figure 2).

FIGURE 2



Steel Chad Foam Center

FEEDBACK: Activity of IP-1

Objective A Check:

Door Types, Thickness/R-Values

Type Door	Thickness		R-Value	
	cm	inches	SI	(US)
Solid wooden door	2.5	1"		
Solid wooden door	3.2	1¼"		
Solid wooden door	3.8	1½"		
Solid wooden door	5.1	2"		
Steel clad foam center door	2.5	1"		
Steel clad foam center door	3.8	1½"		
Steel clad foam center door	5.1	2"		

ENERGY EFFICIENT MATERIALS PART II

IP-2. Energy Efficiency of Materials Used in Various Windows

OBJECTIVE

Upon completion of this instructional package, you will be able to:

A. Name the energy efficiency factors for various windows.

RESOURCES

Study the following selected references before you attempt to perform the activities for IP-2.

Books:

Construction Materials and Processes, 2nd ed. by Don A. Watson, New York, McGraw-Hill Book Company, (Gregg Div.), 1978 pp. 235-242.

Concepts in Thermal Comfort by David M. Egan, Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1975 p. 63.

The Solar Home Book by Bruce Anderson, Harrisville, N.H.: Cheshire Books, 1976 pp. 278-79.

ASHRAE, Handbook of Fundamentals by American Society of Heating Refrigerating and Air-Conditioning Engineers, Inc. New York, N.Y.: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1972.

Pamphlets:

Providing for Energy Efficiency in Homes and Small Buildings, Part III by U.S. Department of Energy, Washington, D.C.: Office of Consumer Affairs, Education Division, 1980 pp. 41-46.

In the Bank or Up the Chimney by U.S. Government Printing Office (2nd ed.) Washington, D.C.: Office of Policy Development and Research, Division of Energy, Building Technology and Standards, U.S. Department of Housing and Urban Development, August 1977 pp. 8, 36.

Instructional Sheets: for IP-2,1 and IP-2,2

ACTIVITY

A. Identification of Window Types (Use instructional sheet IP-2,1)

B. Use instruction sheet IP-2,2 and review the references above for this instructional package and then fill in the blanks on the chart (on attached sheet)

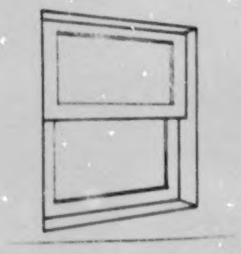
IP-5A,1-.

INSTRUCTIONAL SHEET IP-2,1 Activity IP-2a

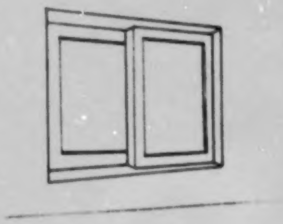
IDENTIFICATION OF WINDOW TYPES

Student Name ______________________________ Score _______/55

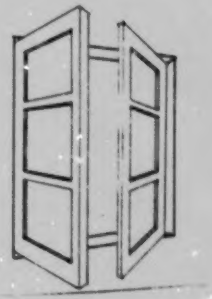
DIRECTIONS: Identify the window types by printing the name under each picture.



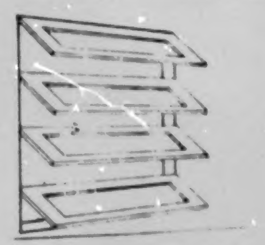
1 ____________________



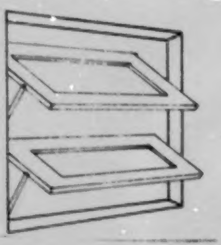
2 ____________________



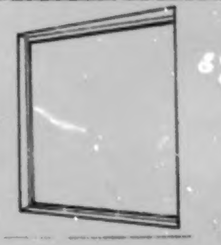
3 ____________________



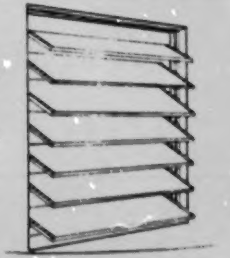
4 ____________________



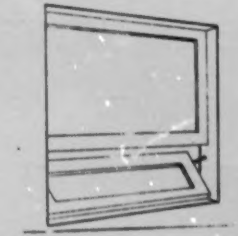
5 ____________________



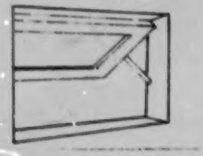
6 ____________________



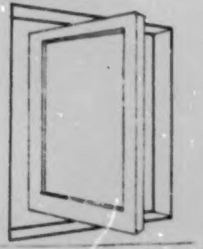
7 ____________________



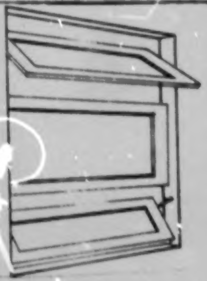
8 ____________________



9 ____________________



10 ____________________



11 ____________________

KEY FOR INSTRUCTIONAL SHEET IP-2,1

Identification of Windows

1. Double Hung
2. Horizontal Sliding
3. Casement
4. Awning
5. Architectural Projected
6. Fixed Glass with Wood Stops
7. Louver or Jalousie
8. Hopper
9. Basement
10. Pivoted
11. Combination Projected and Hopper

*5 points for each correct answer - Total possible is 55 points.

ACTIVITY

Determining "R" values and/or "U" values of the following window glass.

TYPE OF GLASS	THICKNESS	"U" VALUE
Clear	1/8"	
Clear	¼"	
Clear	3/8"	
Clear	½"	
Heat Absorbing	1/8"	
Heat Absorbing	¼"	
Heat Absorbing	3/8"	
Heat Absorbing	½"	

"U"(1) VALUE OF WINDOWS*

DESCRIPTION VERTICAL PANELS	WINTER	SUMMER
Single Pane Flat Glass		
Insulating Glass--Double		
3/6" Air Space		
¼" Air Space		
½" Air Space		
Insulating Glass Triple(2)		
¼" Air Space		
½" Air Space		
Storm Window		
1-4" Air Space		

* ASHRAE - Fundamentals Handbook, 1977.

(1) In units of Btu/hr/$ft^3/^{o}F$

(2) Double and triple refers to number of panes of glass.

ACTIVITY IP-2.2 FEEDBACK KEY

Objective A Check:

DETERMINING "R" VALUES AND/OR "U" VALUES OF THE FOLLOWING WINDOW GLASS

TYPE OF GLASS	THICKNESS	"U" VALUE
Clear	1/8"	0.84
Clear	¼"	0.78
Clear	3/8"	0.72
Clear	½"	0.67
Heat Absorbing	1/8"	0.64
Heat Absorbing	¼"	0.46
Heat Absorbing	3/8"	0.33
Heat Absorbing	½"	0.24

U-VALUE OF WINDOWS

	"U" VALUES	
DESCRIPTION VERTICAL PANELS	WINTER	SUMMER
Single Pane Flat Glass	1.13	1.06
Insulating Glass-double glass		
3/16" Air Space	0.69	0.64
¼" Air Space	0.65	0.61
½" Air Space	0.58	0.56
Insulating Glass-Triple		
¼" Air Space	0.47	0.45
½" Air Space	0.36	0.35
Storm Window		
1-4"	0.56	0.54

(1) In units of Btu/hr/ft^3/°F

(2) Double and triple refers to number of panes of glass.

ENERGY EFFICIENT MATERIALS PART II

IP-3. Energy Efficient Materials for Storm Doors and Windows

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Select storm windows and doors that are energy efficient.

RESOURCES

Read the references below before completing the activities for this instructional package (IP-3).

Pamphlets:

Same as IP-2. (Providing for Energy Efficiency in Homes and Small Buildings, (Part III, pp. 43-44, 47-48)

Same as IP-2. (In the Bank or Up the Chimney, pp. 40-43).

Do it with Windows by North Carolina Energy Division, Raleigh, N.C.: N.C. Energy Division.

Instructional Sheet: for IP-3-Solar Transfer of Single Glass

ACTIVITY

A. Review the information found on the IP-3 Information Sheet on Solar Transmission of Single Glass.

B. Complete work sheet (Figure 1) by answering the questions requested.

INSTRUCTION SHEET IP-3 ON SOLAR TRANSFER OF SINGLE GLASS

SOLAR TRANSMISSION OF SINGLE GLASS*

TYPE GLASS	NOMINAL THICKNESS	SOLAR TRANSMISSION "U" VALUE
Clear	1/8	0.84
Clear	¼	0.78
Clear	3/8	0.72
Clear	½"	0.67
Heat Absorbing	1/8	0.64
Heat Absorbing	¼"	0.46
Heat Absorbing	3/8	0.33
Heat Absorbing	½	0.24

SOLAR TRANSMISSION OF INSULATING GLASS

Clear out, Clear in	1/8	0.71
Clear out, Clear in	¼	0.61
Heat absorbing out, Clear in	¼	0.36

*ASHRAE, Handbook of Fundamentals, 1977, pp. 26-27

FEEDBACK:

Objective A Check:

Student Name ______________________________ Score _____/_____

Answer the following questions:

1. List the tools and materials for installing polyethylene plastic for a storm window.

   a) ______________________________

   b) ______________________________

   c) ______________________________

   d) ______________________________

2. Single pane storm windows may be made of either ____________________ or ____________________.

3. The best finish for an aluminum window frame is ____________________ or ____________________.

4. The major disadvantage of a single piece storm window is ______________________________.

5. The homeowner can save _______ to _______% of the purchase price of storm windows when he installs them himself.

6. You can save a few dollars (_______ to _______) of the purchase price if you install the storm door yourself.

7. The tools needed to install a storm door are a) ____________________

   b) ________________ c) ________________ d) ________________

   e) ________________

Figure 1 Worksheet Efficient Materials for Storm Doors and Windows

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ACTIVITY IP-3 WORKSHEET KEY

1. a) 6-mil polyethylene plastic
   b) 2" wide tape or hammer and tacks
   c) Shears or Scissors
   d) ¼" x 1½" wood slats

2. plastic or glass

3. enamel or anodized

4. They cannot be opened without removing

5. 10 to 15%

6. 10 to 15%

7. a) hammer
   b) screwdriver
   c) drill
   d) weatherstripping
   e) screws and nails

IP-4. Energy Efficient Materials for Floors

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Determine the proper materials to construct an energy efficient floor.

RESOURCES

Read the selected references below before completing the activities for this instructional package.

Pamphlets:

Providing for Energy Efficiency in Homes and Small Buildings, Part III by U.S. Department of Energy, Washington, D.C.: Office of Consumer Affairs, Education Division, 1980 pp. 83-85, Part IV p. 46, Part V p. 61.

In the Bank or Up the Chimney by U.S. Government Printing Office (2nd ed.), Washington, D.C.: Office of Policy Development and Research, Division of Energy, Building Technology and Standards, U.S. Department of Housing and Urban Development, 1977, pp. 21, 23, 58.

Modern Carpentry (Rev. ed.), by Willis Wagner, Homewood, Ill.: Goodheart Willcox, Inc., 1979, Chapter on Floors and Insulation.

Fundamentals of Carpentry by G. Baker and R. Miller, Bloomington, Ill.: McKnight and McKnight Publishing, Inc., 1981 (Chapters on floors and insulation).

The Energy Wise Homebuyer by U.S. Government Printing Office, Washington, D.C.: Supt. of Documents, U.S. Government Printing Office (GPO-#023-000-00518-2).

ACTIVITY

A. Read the above references for instructional package IP-4. Then answer the questions and do the problems.

1. Locate your geographical area on the map and determine the "R" factor for efficiency insulating your home.

   Zone ______________ Type heat __________________ "R" factor ___________

2. What type of insulation is most commonly used in the floor of a house?

3. What is the recommended "R" value for floors for the following geographical zones and types of heat?

   A. Zone A a) electric heat __________________
   b) gas oil heat pump ______________

   B. Zone B a) electric heat __________________
   b) gas oil heat pump ______________

   C. Zone D a) electric heat __________________
   b) gas oil heat pump ______________

4. _____ Insulation installed with a vapor barrier attached, the vapor barrier is to the
   A. warm side B. cold side

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ACTIVITY IP-4 ACTIVITY SHEET KEY

Objective A Check:

1. Zone C - Raleigh, N.C.
   Electric Heat R-19
   Gas Oil Heat Pump R-11

2. Batts

3. Zone A a) electric heat - none
   b) gas oil heat pump - none

   Zone B a) R-11
   b) none

   Zone D a) R-11
   b) R-19

4. A

ENERGY EFFICIENT MATERIALS PART II

IP-5. Energy Efficient Materials for Ceilings and Attics

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Select energy efficient materials for ceilings and attics.

RESOURCES

Before starting the activities for this instructional package (IP-5) read the selected references.

Pamphlets:

Same as IP-2. (Providing for Energy Efficiency in Homes and Small Buildings, Part III, pp. 75-83, Part IV pp. 44-5, Part IV pp. 57-60.

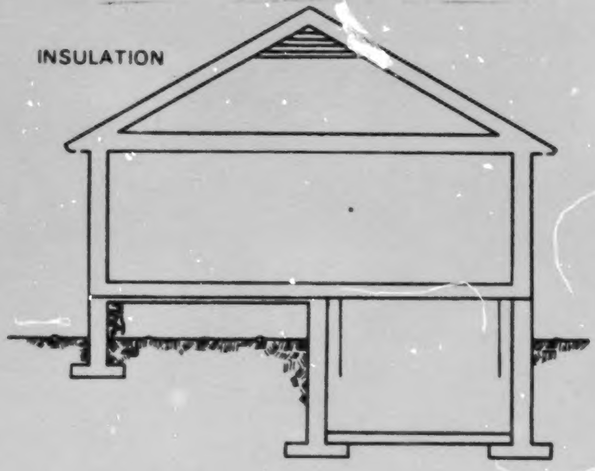
Same as IP-2. (In the Bank or Up the Chimney, pp. 11-16, 47-54.)

ACTIVITY

Given the diagrams of the four houses below place the proper insulation in the ceilings and attics for an energy efficient house (be specific).

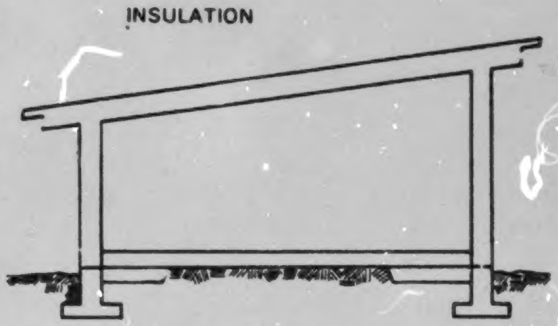
Zone A

Insulation


INSULATION

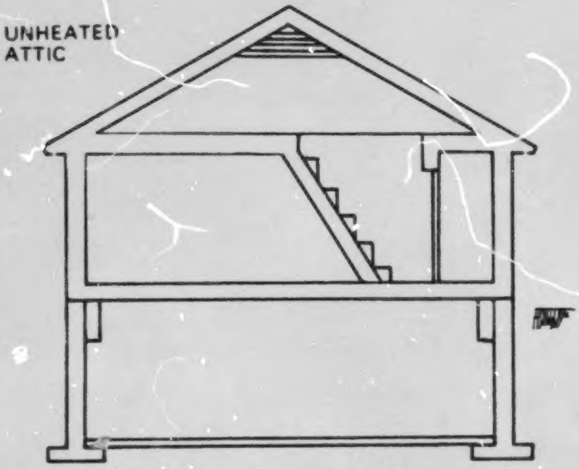
Zone B

Insulation


INSULATION

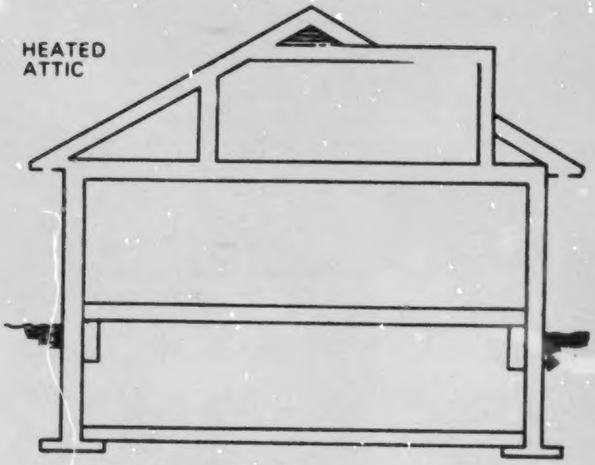
Zone C

Unheated Attic


UNHEATED ATTIC

Zone D

Heated Attic


HEATED ATTIC

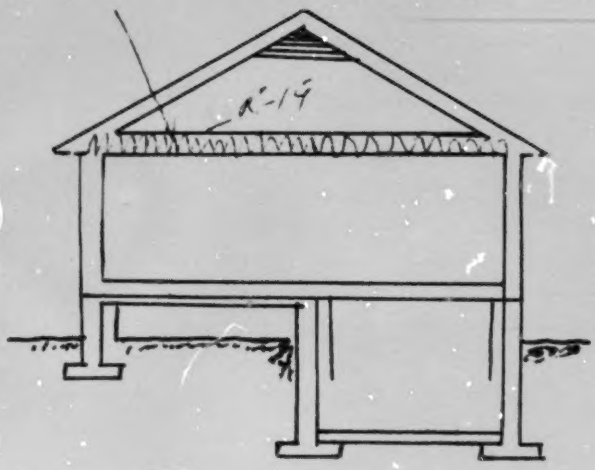
FEEDBACK:

Objective A Check:

Insulate the ceiling and attic with proper amounts of insulation.

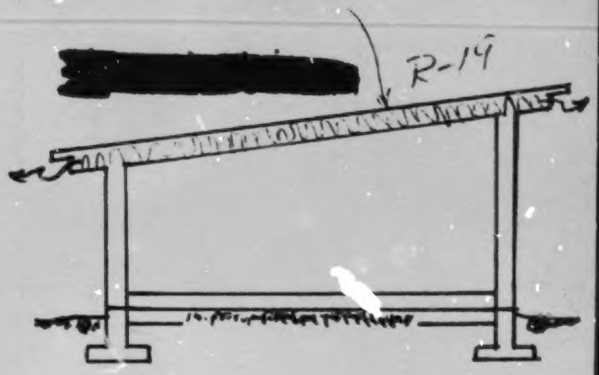
Zone A

Insulation



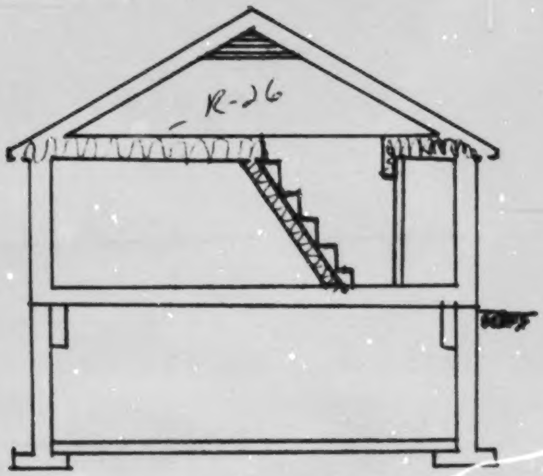
Zone B

Insulation


[redacted]

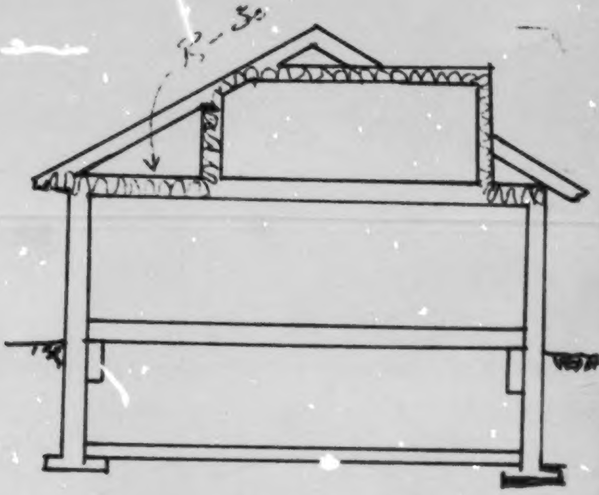
Zone C

Heated Attic



Zone D

Unheated Attic



ENERGY EFFICIENT MATERIALS PART II

IP-6. Energy Efficient Materials Used in Lighting

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Select types of lighting that would be energy efficient.

RESOURCES

Read the references below before attempting to do the activities for this instructional package.

Pamphlets:

Same as IP-2. (Providing for Energy Efficiency in Homes and Small Buildings, Part III, pp. 67-8, 108, Tables XIII, XIV, XV, p. 69.)

Same as IP-2. (In the Bank or Up the Chimney, p. 72.)

Book:

Construction Materials and Processes, 2nd ed. by Don A. Watson, New York, N.Y.: McGraw-Hill Book Co. (Gregg Div.) 1978, pp. 440-444.

ACTIVITY

A. Identify the required lighting that is efficient for selected task.

TABLE OF RECOMMENDED ILLUMINATION LEVELS

TYPE OF WORK	FOOTCANDLES ON TASK	$^{lm}/_{m^2}$
Residential:		
Living room, dining room, bedroom, entrance, hallways, stairways and family room		
Kitchen, laundry, bathroom		
Kitchen work surfaces and range		
Shaving and make-up mirrors		
Sink, workshop, reading fine print		
Sewing		
Office:		
Corridors, elevators, stairways		
Interviewing rooms, reception rooms, washrooms		
Reading or writing		
General office work, typing, filing		
Accounting, auditing, bookkeeping		
Detail drafting		

ACTIVITY IP-6 FEEDBACK KEY

Objective A Check:

TYPE OF WORK	FOOTCANDLES ON TASK	$^{lm}/_{m^2}$
Residential:		
Living room, dining room, bedroom, entrance, hallways, stairways and family rooms	10	108
Kitchen, laundry, bathroom	30	323
Kitchen work surfaces and range	50	538
Shaving and make-up mirrors	50	538
Sink, workshop, reading fine print	70	753
Sewing	100	1078
Office:		
Corridors, elevators, stairways	20	215
Interviewing rooms, reception rooms, washrooms	30	323
Reading or writing	70	753
General office work, typing, filing	100	1078
Accounting, auditing, bookkeeping	150	1615
Detail drafting	200	2153

POST-CHECK

ENERGY EFFICIENT MATERIALS PART II

DOORS, WINDOWS, STORM DOORS AND WINDOWS, FLOORS, CEILINGS, ATTICS AND LIGHTING

Post-Test: Check for Doors, Windows, Storm Doors and Windows, Floors, Ceilings, Attics and Lighting

DIRECTIONS: Write appropriate answer in the blank on the left margin for each question.

IP-1

_____ 1. List types of doors according to highest to lowest "R" values:
- A. hollow core
- B. solid wood
- C. steel-clad foam center

_____ 2. The best insulating storm door is:
- A. metal and glass
- B. wood and glass
- C. solid metal

_____ 3. Fill in chart below:

	THICKNESS		"R" VALUE	
TYPE OF DOOR	cm	inches	si	(US)
Steel clad-foam center	5.1		1.92	
Solid wooden door	2.5	1"	.27	
Solid wooden door	3.2		.32	
Steel clad-foam center	2.5	1"	1.38	

IP-2

_____ 1. Aluminum frame windows have a lower R-value than wooden frame windows.
- A. True
- B. False

_____ 2. Jalousie windows are energy efficient.
- A. True
- B. False

POST-CHECK

(Continued)

IP-2

_____ 3. Window space in a building:
- A. improves energy efficiency
- B. reduces energy efficiency
- C. makes no difference in energy efficiency

_____ 4. The most effective of the following ways to improve efficiency of windows is:
- A. add single glazed storm windows
- B. install triple glazed window with storms
- C. add plastic sheeting on outside
- D. none of the above

_____ 5. Windows help prevent air infiltration.
- A. True
- B. False

_____ 6. Which type of window is most energy efficient?
- A. double hung
- B. jalousie
- C. awning
- D. architectural projected

IP-3 Storm Doors and Storm Windows

_____ 1. Window glass is a poor insulator.
- A. True
- B. False

_____ 2. The type storm window with the best "R" value is:
- A. glass with wooden frame
- B. glass with aluminum frame
- C. rigid plastic
- D. flexible plastic

_____ 3. Glass with aluminum frames is the most durable.
- A. True
- B. False

_____ 4. When fitting storm windows, measure:
- A. one window and get storm windows for all windows the same size
- B. all windows and fit each individual window

_____ 5. Double glazing combination windows will reduce heat loss by:
A. 1/10 B. 2/3 C. ½

POST-CHECK

(Continued)

IP-3 cont.

_____ 6. Aluminum combination storm windows can be used on:
A. all types of windows
B. only double hung or horizontal sliding glass
C. awning type windows

_____ 7. Flexible plastic is:
A. an inexpensive temporary installation
B. a permanent type installation

_____ 8. Flexible plastic may be installed:
A. inside B. outside C. either inside or outside

_____ 9. To install storm doors, screen doors must be:
A. left in place
B. removed

_____ 10. A storm door is hung on:
A. the inside casing of the door to open inward
B. the outside casing of the door to open outward

IP-4 Energy Efficient Materials for Floors

_____ 1. On perimeter insulation of a slab floor you would use:
A. batts (with no vapor barrier)
B. reflective
C. rigid
D. fiber glass

_____ 2. Flexible insulation is supported under finished floors by:
A. heavy gauge wire B. wire mesh C. either of the above

_____ 3. Flexible insulation is easier to install in floors:
A. before the subfloor is laid
B. after the house is finished

_____ 4. Rigid insulation may be used in the following types of floors:
A. existing slab floors
B. wood floors
C. new slab floors
D. all of the above

_____ 5. Utilizing the diagram below indicate the type of insulation that you would install in the floor of each house.

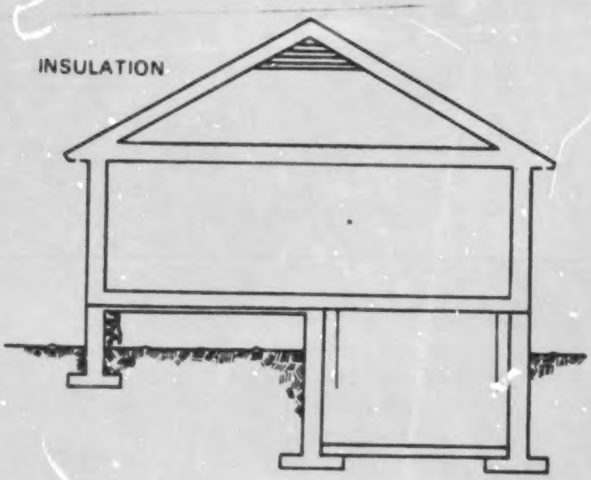
POST-CHECK

(Continued)

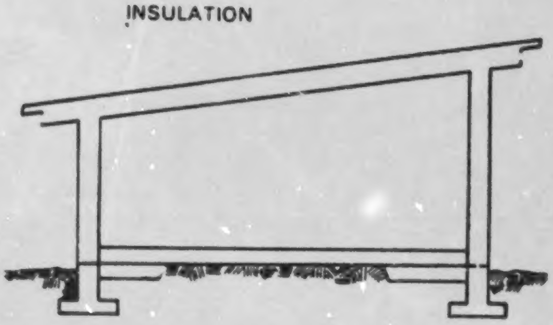
IP-4

5. Utilizing the diagram below indicate the type of insulation that you would install in the floor of each house.

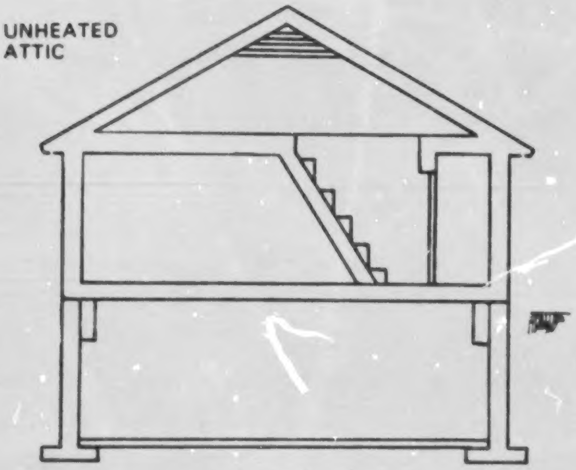
Insulation


INSULATION

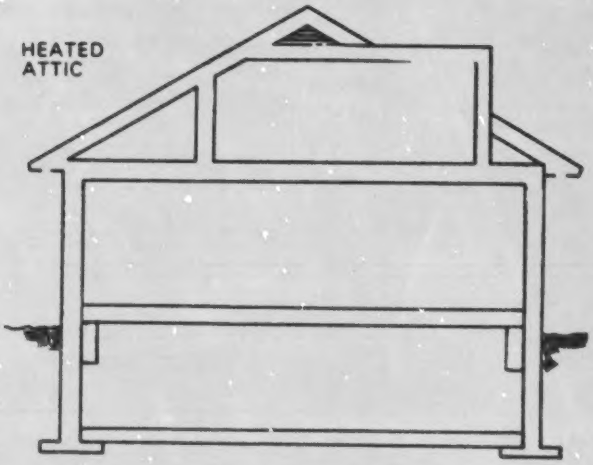
Insulation


INSULATION

Unheated Attic


UNHEATED
ATTIC

Heated Attic


HEATED
ATTIC

POST-CHECK

(Continued)

IP-5 Energy Efficient Materials for Ceilings and Attics

_____ 1. Insulation should be installed in a new or remodeled building:
A. as each component part is completed
B. after all framing is done and electrical, plumbing, heating and cooling are roughed in
C. after the building is completed

_____ 2. The purpose of insulation is to:
A. keep out moisture
B. strengthen the structure
C. improve the thermal efficiency

_____ 3. For buildings which have no attic and insulation is installed next to the roof
A. air space is required between insulation and roof
B. air space is not required
C. air space is required between insulation and ceiling

_____ 4. When installing flexible or loose-fill insulation in the attic:
A. be sure to pack insulation against the cornice to prevent air from entering the attic through the soffit vents
B. avoid restricting attic ventilation through the soffit vents

_____ 5. When installing flexible insulation
A. wear short sleeve and loose fitting clothes
B. wear a chemical respirator
C. wear safety goggles, dust mask, and clothes that fit tight around the neck and wrists

_____ 6. When adding flexible insulation to the ceiling:
A. lay all blankets or batts parallel to joist
B. lay insulation parallel to joist until space is filled, then lay extra at right angles to joist
C. lay all insulation at right angles to joist

_____ 7. When installing a blanket or batt insulation:
A. leave spaces between joist for expansion
B. pack insulation in tightly
C. place insulation loosely leaving no spaces between joists or around receptacles and pipes

_____ 8. If the vapor barrier backing is reflective foil:
A. the backing must be stapled to the inside edge of the joist and an air space provided
B. the backing must be stapled to the outside edge of the joist

POST-CHECK

(Continued)

IP-5

____ 9. If the insulation has a vapor barrier, the vapor barrier should be placed:
- A. next to the heated side
- B. next to the exposed (cold) side
- C. does not matter

IP-6 Energy Efficient Materials Used in Lighting

____ 1. Two types of natural lighting that can be used to improve our visual comfort are ____________________ and ____________________.

____ 2. Which of the two types of artificial lights expensive to install?
A. fluorescent B. incandescent

____ 3. The term lumens means
A. type of light B. light emitted C. amount of power used

____ 4. Which of the following lights gives the largest amount of lumens?
A. incandescent B. high intensity C. fluorescent

____ 5. Long life bulbs furnish what percentage of light as a regular bulb?
A. 50% B. 70% C. 80%

POST-TEST KEY

NOTE: This key should be kept separate from remainder of module and furnished only to instructor.

IP-1

1. C, B, A

2. B

3. see chart below

TYPE DOOR	THICKNESS cm	THICKNESS inches	"R" VALUE Si	"R" VALUE (US)
Steel clad foam center	5.1	2"	1.92	10.94
Solid wooden door		1"	.27	1.56
Solid wooden door	3.2	1¼"	.32	1.82
Steel clad foam center	2.5	1"	1.38	7.8

IP-2

1. A
2. B
3. B
4. B
5. B
6. A

IP-3

1. A
2. A
3. A
4. B
5. C
6. B
7. A
8. C
9. B
10. B

IP-4

1. C
2. C
3. A
4. D
5. see (1P-4 Q5)

POST TEST KEY

(Continued)

IP-5

1. B
2. C
3. A
4. B
5. C
6. B
7. C
8. A
9. A

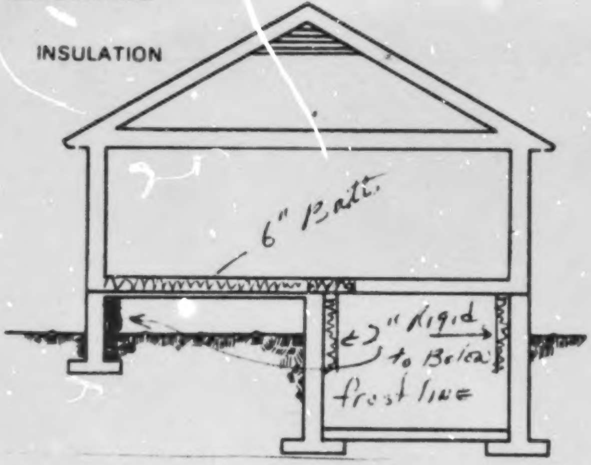
IP-6

1. windows, skylights
2. A
3. B
4. C
5. C

IP-5 Question 5 KEY

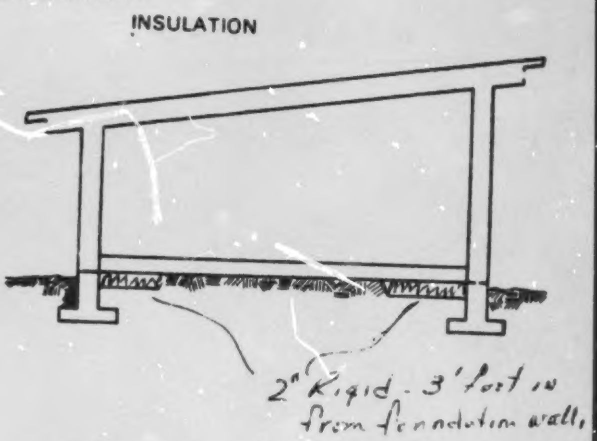
5A

Insulation


INSULATION
6" Batts
2" Rigid to Below frost line

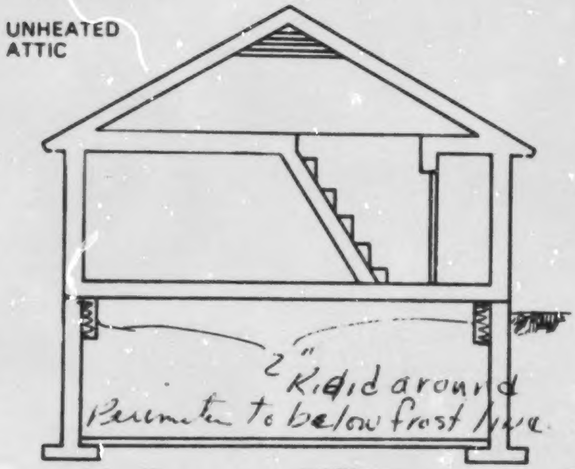
5B

Insulation


INSULATION
2" Rigid - 3' foot in from foundation wall.

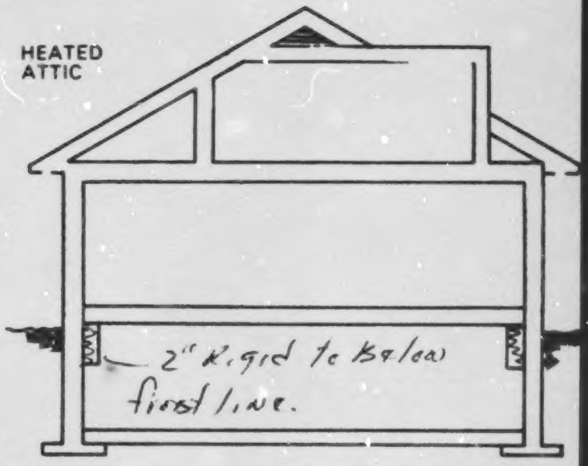
5C

Unheated Attic


UNHEATED ATTIC
2" Rigid around Perimeter to below frost line

5D

Heated Attic


HEATED ATTIC
2" Rigid to Below frost line.

5A - 6" batts with vapor barrier up to warm side (crawl space)
2" rigid on exterior foundation walls to below frost line
5B - 2" rigid - 3' in from foundation wall
5C - 2" rigid round perimeter to below frost line
5D - 2" rigid aound perimeter to below front line

MODULE SEVENTEEN

ENERGY CONSERVATION IN PRIVATE TRANSPORTATION
(EXCLUDING MAINTENANCE AND DRIVING HABITS)

Prepared

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Conservation for IAE at North Carolina State University
June 1981-R.E. Wenig, Director

ENERGY CONSERVATION IN PRIVATE TRANSPORTATION
(EXCLUDING MAINTENANCE AND DRIVING HABITS)

Private transportation is vital to Americans' way of life. With fuel cost consistently rising more and more of the person's budget will be toward paying for private transportation. Those who complete this module be able to reduce cost of private transportation and yet keep their way of life.

TERMINAL PERFORMANCE OBJECTIVE

Upon completion of this module the student will: (1) identify five techniques that a family might use to conserve energy in the family transportation needs, (2) list advantages and disadvantages of each technique and discuss the feasibility of each technique in the family situation, (3) devise a plan which would utilize each of the five techniques, (4) compute the typical fuel, mileage or time savings, and (5) compute the annual savings in monetary terms if all feasible techniques were utilized.

Achievement of the terminal performance objectives will be accomplished by successfully completing the five instructional packages (IP-1-5). Prior to satisfying the IP requirements a pre-check evaluation will be required to determine an individual's level of technical competency.

The results of the pre-check may be used to diagnose and prescribe the IPs that are required to complete the instructional module.

Individuals unfamiliar with the technical data of this module should omit the pre-check and begin IP-1. Those who take the PRE-CHECK should record the results in the following section.

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1.	Energy Savings in the Private Transportation Sector by the Multiple Objective Technique	___	___
IP-2.	Energy Savings in the Private Transportation Sector by the Family Pooling (Consolidated Trip) Technique	___	___
IP-3.	Energy Savings in the Private Transportation Sector by the Planned Time Technique	___	___
IP-4.	Energy Savings in the Private Transportation Sector by the Planned Route Technique	___	___
IP-5.	Energy Savings in the Private Transportation Sector by the Alternate Mode Technique	___	___

PRE-CHECK

ENERGY CONSERVATION IN PRIVATE TRANSPORTATION
(EXCLUDING MAINTENANCE AND DRIVING HABITS)

DIRECTIONS: **Place a "T" for true and an "F" if the answer is false beside the question in the space provided.**

IP-1. Energy Savings in the Private Transportation Sector by the Multiple Objective Technique

_____ 1. One advantage of the multiple objective technique of making one longer round trip instead of three or four short trips is that the automobile will get better miles per gallon.

_____ 2. The use of a shopping list is an aid to the purchaser in establishing the minimum route.

_____ 3. A motorist's normal or average city driving mileage is 18 mpg. If he picks up three riders he will still average 18 mpg.

_____ 4. A wise shopper will clip the coupon from the morning paper and drive immediately to the grocery store so as to benefit from the coupon savings.

_____ 5. The energy conscious driver will cruise around the mall looking for a parking place nearest to the center of the stores involved in the shopping.

_____ 6. A warm engine is more fuel efficient than a cold engine.

IP-2. Energy Savings in the Private Transportation Sector by the Family Pooling (Consolidated Trip) Technique

_____ 1. Assuming it is 10 miles to work, the ideal number of riders for a car pool would be 6.

_____ 2. Combining a shopping trip with a pick-up at the school in the same general area can reduce fuel consumption as much as 20% to 30%.

_____ 3. For economy it is best to put the heavy packages in the trunk and the heavier passenger in the rear seat.

_____ 4. A luggage rack is beneficial from the fuel economy standpoint as it enables the driver to carry more passengers and a heavier shopping load.

_____ 5. Since urban family pooling results in carrying more weight, it is advisable to pump up the tires and thereby save gasoline.

_____ 6. It is possible that the use of an air conditioner during city driving can offset the benefits or consolidating trips.

IP-3 Energy Savings in the Private Transportation Sector by the Planned Time Technique

_____ 1. It is best to plan the trip during a rain as better economy will result from the cooler, moister conditions.

_____ 2. Accelerating fully from the stop light so as to get ahead of the rush hour traffic will enable the motorist to increase the mileage per gallon.

_____ 3. Driving in peak traffic not only lessens fuel economy, it results in an increase in exhaust emissions.

_____ 4. The legal interstate speed limit of 55 mph was selected because:
A. it is a safer speed for the average motorist
B. it is the slowest speed that the American driving public will tolerate
C. driving at 55 mph is a good average speed which can save considerable fuel
D. Cars emit less exhaust emissions than at most other speeds

_____ 5. At 50 miles per hour the car is traveling about _____ feet per second; scan will be a little over _____ ahead.
A. 30 feet per second, 360 feet
B. 45 feet per second, 1/10 of a mile
C. 60 feet per second, 2 football field lengths
D. 75 feet per second, 3 football field lengths

_____ 6. Assuming motorist A drives 5 miles in 20 minutes. Motorist B drives the same 5 miles in 15 minutes. The percentage of fuel savings is
A. 15% B. 25% C. 35% D. 45%

IP-4. Energy Savings in the Private Transportation Sector by the Planned Route Technique

1. What is the significance of the "Don't Walk" display to the motorist?

_____ 2. A poor driver can diminish his fuel economy by as much as:
A. 5% B. 15% C. 25% D. 35%

_____ 3. The average duration of the red light is:
A. 10 seconds B. 15 seconds C. 20 seconds D. 25 seconds E. 30 seconds

_____ 4. If a driver sees the light ahead turn yellow he should turn off the ignition, put transmission into neutral and coast until necessary to brake for the stop light. This will improve his economy.

_____ 5. It is usually feasible to go through the green light for a block and make 3 consecutive right turns and through the green light rather than to try to turn left across traffic.

_____ 6. It is generally an accepted practice to use a higher octane fuel than specified. The car will get enough better mileage to offset the 4¢ to 5¢ per gallon higher cost.

IP-5. Energy Savings in the Private Transportation Sector by the Alternate Mode Technique

_____ 1. Generally an alternate mode of transportation sacrifices time and convenience for gasoline economy.

_____ 2. On the average a two ton family sedan uses about 40% more gasoline that a one ton subcompact.

_____ 3. When comparing costs of alternate modes of transportation, one must also include capital outlay.

_____ 4. The least fuel consuming form of an alternate transportation mode but not always feasible is also the oldest -- walking.

_____ 5. If you purchased a bicycle for $169.00 so as to save gasoline, and the bicycle's estimated life is 34 weeks per year for five years, what is the pro-rated cost per week?

PRE-CHECK ANSWERS

IP-1

1. T
2. T
3. F
4. F
5. F
6. T

IP-2

1. F
2. T
3. F
4. F
5. F
6. T

IP-3

1. F
2. F
3. T
4. C
5. D
6. B

IP-4

1. The "Don't Walk" display tells the motorist that the green will soon change to yellow. He should estimate whether he will have to stop or can make it on the green.
2. D
3. C
4. F
5. F
6. F

IP-5

1. T
2. T
3. T
4. T
5. Very close to $1.00 per week

FEEDBACK: Instructional Package 1

Objective A Check:

1. List four additional categories of family purchases such as groceries, hardware, etc.

Objective B, C & D Check:

2. Compute the total mileage and costs of the following:

   A. One way trip of ½ mile, 2 miles, 3 miles and 1¼ miles @16 miles per gallon and $1.35 per gallon.

3. Compute the total mileage and cost of the following: multiple objective trip:

   A. Trip of ½, 3/4, 1.3 and 1 mile at 16 miles per gallon at $1.35 per gallon.

4. From the following map compute the total mileage for a round trip to Store A and a round trip to Store B. Compute a trip to Store A to Store B and home. At 18 mpg and $1.239 per gallon, how much fuel and money are saved?

2½ miles

Store A # #Store B

2 miles

3.2 miles

Home #

ACTIVITY

A. Scotch tape or pin a shopping list on the kitchen wall. Similarly tape a calendar of family activities in a nearby place. Coordinate the family business activities so as to reduce the many short trips into one larger round trip.

B. Using a city map select the route which would enable the family car to include the stops in the shortest distance.

C. Plan one of the essential trips and record the time required to complete the trip and the resulting mileage.

D. Record the time and mileage required to complete the same stops in the previous uncoordinated or unplanned random method.

E. Compare the time and the mileage required for the two methods.

F. Draw conclusions concerning random method time and mileage requirements and the multiple objective use time and mileage requirements.

G. Convert the mileage savings into monetary terms.

FEEDBACK KEY: Instructional Package 1

1. Groceries, hardware, drugs and prescriptions, gasoline, dry cleaners, appliances and furniture, professional services

2. 6 3/4 miles x 2 = 13½ miles

   $\frac{13\frac{1}{2}}{16} \times \$1.35 = \frac{182.25}{16} = \$1.14$

3. $\frac{6\frac{1}{4} \text{ miles}}{16} \times \$1.35 = \frac{8.4375}{16}$

4. 4 miles + 6.4 miles = 10.4 miles

   $\frac{10.4}{18} \times 1.239 = \$.72$

   2 miles + 2½ miles + 3.2 miles = 7.45 miles

   $\frac{7.45}{18} \times 1.239 = \frac{.923055}{18} = \$.51$

   Savings .72 - .51 = \$.21

   OR 10.4 - 7.45 = 2.95 miles

   $\frac{2.95}{18} \times \$1.239 = \$.20$

ACTIVITY

A. Scotch tape or pin a calendar next to the shopping list on the kitchen wall. Coordinate the business and social activities so as to reduce the number of trips to a fewer number of trips.

B. Record the number of trips taken, the mileage required for one week of non-car pooled travels.

C. Record the number of trips taken, the mileage required for one week of car pooled activities.

D. Compare the time and the mileage required for the random method and the family pooling method.

E. Convert the mileage savings into monetary terms.

460

FEEDBACK:

Objective A Check:

_____ 1. Car pooling is a proven energy saving technique. Similar scheduling of family social and business activities is known as:
   A. combining trips
   B. family pooling
   C. consolidation of trips
   D. all of the above

2. Assume the following: 10 round trips to school each week at 3/8 mile from home to school. Also trips at distances of ½ mile one way, 1¼ miles one way, .75 miles one way, .6 miles one way and 1 mile one way. What is the total mileage for the week?

Objective B Check:

3. Consider the following: Trips of 1 mile, 2 1/8 miles, 1.25 miles, 1.375 miles, 1.2 miles and 2 miles. What is the total mileage for the week?

Objective C Check:

4. Exercise 2 is a week of non-pooled driving. Exercise 3 is a combined business and school trip for the week. How much gasoline was saved during the week if the car averages 18.5 mpg urban driving? How much gasoline was saved during the school year of 32 weeks?

Objective D Check:

5. At $1.38 per gallon what is the school year savings?

FEEDBACK KEY:

1. D

2. 15.7 miles

3. 8.95 miles

4. 15.7 - 8.95 = 6.75 miles saved

$\frac{6.75}{18.5}$ = .365 gallons saved per week X 32 weeks

= 11.67 gallons saved per school year

5. 11.67 gallons X $1.38 per gallon = $16.11

ACTIVITY

A. Using a city map plan a route necessary to conduct family business or social activities using car pooling or multiple objective techniques.

B. Following the map record the driving time necessary to complete the route during non-peak traffic hours.

C. Following the map record the driving time necessary to complete the route during peak traffic hours.

D. Convert the savings in time to savings in fuel using approximate urban fuel consumption for the family car model.

E. Convert the fuel savings into monetary terms.

FEEDBACK:

Objective A-E Check:

_____ 1. Maintaining a constant speed is most difficult in
- A. open road driving
- B. city driving
- C. interstate driving
- D. rush hour traffic

_____ 2. If you see a red light far ahead, you should:
- A. speed up
- B. start braking immediately
- C. select the lane with the fewest number of cars
- D. start slowing and try to gauge your speed to pass the light while green

_____ 3. Tailgating is an unacceptable driving technique as it:
- A. saves gasoline for all cars involved
- B. enables each motorist to maintain a constant speed
- C. enables each motorist to conserve
- D. is hazardous and not effective except on the race track

_____ 4. Jackrabbiting describes a driving mode in which the motorist:
- A. accelerates rapidly when starting
- B. decelerates severely when stopping
- C. wastes energy
- D. all the above

_____ 5. When planning a route through the city to conserve energy one would avoid:
- A. peak rush hour traffic
- B. stop signs
- C. construction zones
- D. left turns
- E. all of the above

FEEDBACK KEY:

1. D
2. D
3. D
4. D
5. D

ACTIVITY

A. Using a city map mark the route taken by the driver of the family car in completing the stops planned utilizing the family pooling or multiple objective technique.

B. Record the time required and the mileage traveled for the trip.

C. Using the city map plan the route including the same stops noting 4-way stop intersections, stop-go lights, preferential streets, uncontrolled intersections, and other conditions which affect rate of speed, variation of speed and idling time.

D. Record the time required and the mileage traveled for the trip.

E. Convert the savings in time to savings in fuel using approximate urban fuel consumption figures for the model of the family car.

F. Convert the fuel savings into monetary terms.

FEEDBACK:

Objective A-F Check:

_____ 1. Maintaining a steady speed and not varying more than 5 miles per hour can save as much as:
A. 1.3 miles per gallon highway driving
B. 5.0 miles per gallon highway driving
C. 7.2 miles per gallon highway driving
D. 9.0 miles per gallon highway driving

_____ 2. Jerky acceleration can decrease city driving's miles per gallon by as much as:
A. 1 mile per gallon
B. 2 miles per gallon
C. 4 miles per gallon
D. no effect on consumption

_____ 3. The least fuel consumption for passenger cars per mile is:
A. 25-45 miles per hour
B. 35-55 miles per hour
C. 45-65 miles per hour
D. 55-75 miles per hour

_____ 4. At idling the mileage per gallon is:
A. 20 B. 15 C. 10 D. 5 E. 0

_____ 5. Starting an engine takes slightly less gasoline than _____ seconds of idling.
A. 10 B. 20 C. 30 D. 40 E. 50

FEEDBACK KEY:

1. A
2. B
3. B
4. E
5. C

ACTIVITY

A. Read the resource materials and give an example of how each transportation mode or technique could be used to meet family needs or personal needs.

B. The student will compile a list of transportation needs for himself for one typical week using the family car.

C. From the transportation needs list the student will select those trips for one week which would be feasible using an alternate mode such a bicycle, moped, motorcycle or on foot.

D. Using the appropriate miles per gallon of the family (or student) automobile, compute the fuel consumed in a typical week meeting the transportation needs of the student.

E. If operating costs are incurred using the selected alternate mode, compare the consumption for a typical week with the automobile consumption for the same activities. The difference represents an energy savings.

F. Convert fuel consumption weekly figures to cost per mile and multiply by the number of weeks of alternate mode use to secure annual operating cost savings.

FEEDBACK:

Objective A-F Check:

1. Explain how a motorist averaging 30 miles per hour can use more fuel than a motorist averaging 40 miles per hour.

2. Carrying 200 pounds of sand in the trunk to increase traction for winter driving will reduce mileage by
   A. 2%   B. 12%   C. 22%   D. 32%   E. 42%

3. A 5% reduction in miles per gallon in a car which averages 30 miles per gallon with gasoline costing $1.439 a gallon costs:
   A. 5.4¢   B. 6.0¢   C. 6.6¢   D. 7.2¢   E. 8.0¢

4. Explain how a motorist can avoid making a left turn at an uncontrolled intersection during rush hour?

5. If the student purchased a $126.00 bicycle to avoid driving to school each day, he could use his bicycle on the average of 4 days per week 32 weeks for the school year. Bicycle life is estimated to be 5 years. Round trip to school is 3½ miles. The family car is operational and capital costs are 45¢ per mile total. The car averages 18 mpg. What is the total number of miles to school, the costs of each mode, the savings in dollars by riding the bicycle and the number of gallons saved?

FEEDBACK KEY:

1. A motorist averaging 30 miles per hour can use more gasoline than a motorist going 40 miles per hour by:
    - A. riding on the brake pedal with his left foot
    - B. not releasing the emergency brake completely
    - C. "kicking" and "coasting" constantly
    - D. longer acceleration and late hard braking

2. A

3. D

4. By turning left and **paralleling the preferential highway until intersecting with a cross road with a stop-go light.** Turn on the cross road to the right, proceed to the light and then turn left at the light.

5. 416 miles per school year. Bicycle costs are $25.20. Automobile costs are $185.60. Savings are $160.40 per year. Gasoline savings are 14 gallons per school year.

POST-CHECK

ENERGY CONSERVATIONS IN PRIVATE TRANSPORTATION

DIRECTIONS: Provide the appropriate response that answers the questions.

1. List four advantages of car pooling or family pooling.

2. To conserve gasoline it is recommended that a driver accelerate slowly. Is there a time when slow acceleration is not acceptable?

3. If the average car loses about 1 mpg for each 5 mph over 50, what will be the mpg at 70 mph if the car averages 22 mpg at 50?

4. If braking changes kinetic energy into heat energy what is the energy change when accelerating?

5. Discuss how rush hour traffic increases fuel consumption.

6. If 5 miles are saved each week of the year by consolidating trips and the family averages 15 miles per gallon, how many gallons and how much money is saved annually at $1.38 per gallon?

ENERGY CONSERVATION IN PRIVATE TRANSPORTATION

IP-1 Energy Savings in the Private Transportation Sector by the Multiple Objective Technique

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Select stores and establishments appropriate to needed purchases.

B. Plan an appropriate route to the selected stores.

C. Demonstrate the planning necessary for purchasing to meet family needs.

D. Convert mileage savings into monetary units.

RESOURCES

Pamphlets:

Same as IP-5.

Books:

Same as IP-5.

POST-CHECK KEY

1. Saves time, saves energy in the form of gasoline, saves wear on the automobile, results in less pollution, **uses fewer** parking spaces and less traffic congestion.

2. Entering interstate on the on-ramp, passing another car on two lane roads.

3. 20 - 4 = 16 mpg

4. Chemical energy is changed to mechanical energy

5. Rush hour traffic is erratic and thus much accelerating and decelerating using excessive fuel.

   More time spent idling at stops with more fuel being used while idling.

   More starting, stopping and braking thus more fuel consumption.

6. 17.5 gallons - $23.87

ENERGY CONSERVATION IN PRIVATE TRANSPORTATION

IP-2 Energy Savings in the Private Transporation Sector by the Family Pooling (Consolidated Trip Technique)

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Schedule business and social activities so as to consolidate many short trips into one longer trip.

B. Plan an appropriate route to include the scheduled activities.

C. Compute the time and mileage savings of the family pooling method and the random method.

D. Convert mileage savings into monetary terms.

RESOURCES

Pamphlets:

Same as IP-5.

Books:

Same as IP-5.

IP-3 Energy Savings in the Private Transportation Sector by the Planned Time Technique

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Plan a typical trip and route using the multiple objective technique or the family pooling technique.

B. Compare the time savings for a trip made during peak and non-peak traffic hours.

C. Compare the fuel savings for a trip made during peak and non-peak traffic hours.

D. Approximate fuel consumption based upon time **en route.**

E. Convert fuel consumption savings into monetary units.

RESOURCES

Pamphlets:

Same as IP-5.

Books:

Same as IP-5.

ENERGY CONSERVATION IN PRIVATE TRANSPORTATION

IP-4 Energy Savings in the Private Transportation Sector by the Planned Route Technique

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Plan routes to avoid left turns at uncontrolled intersections.

B. Plan trips to utilize preferred routes.

C. Plan routes so as to capitalize on the green light at controlled intersections.

D. Recognize traffic patterns and to adjust speed so as to drive smoothly and at a uniform speed along the selected route.

E. Approximate fuel consumption based upon time en route.

F. Convert fuel consumption savings into monetary terms.

RESOURCES:

Pamphlets:

Same as IP-5.

Books:

Same as IP-5.

ENERGY CONSERVATIONS IN PRIVATE TRANSPORTATION

IP-5 Energy Savings in the Private Transportation Sector by the Alternate Mode Technique

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Compute costs of transportation using the family or personal car for **activities.**

B. Compute prorated costs of non-motorized alternate modes of transportation.

C. Compute operating costs of motorized alternate modes of transportation.

D. Discuss the advantages and disadvantages of the alternate modes of transportation.

E. Be aware of the relative costs versus the time and convenience factors of alternate modes of transportation.

F. Approximate the annual accrued savings **on transportation needs using alternate modes of transportation.**

RESOURCES

Pamphlets:

350 Ways to Save Energy (and Money) in Your Home and Car by Henry R. Spies et al., Crown Publishers, Inc., New York, N.Y., 1974.

16 Steps to Conserve Energy on Our Highways by Frances W. Stanley, North Carolina Department of Commerce, 1978.

Mileage Makers Tips by Amoco Educational Services, Chicago, Illinois.

1980 Gas Mileage Guide by Fuel Economy Distribution Technical Information Center, Department of Energy, Oak Ridge, Tennessee, 1980.

Books:

Economy Driving by Doug Roe, HP Books, Tucson, Arizona.

MODULE EIGHTEEN

ENERGY CONSERVATION IN PUBLIC TRANSPORTATION

Prepared

by

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Department of Industrial Arts and Technology
Elizabeth City State University
Elizabeth City, North Carolina

USDOE Sponsored Faculty Development Workshop on Energy
Conservation for IAE at North Carolina State University
June 1981 - R.E. Wenig, Director

ENERGY CONSERVATION IN PUBLIC TRANSPORTATION

Public transportation utilizes approximately 26% of the total energy in the United States. A large portion of this energy comes in the form of petroleum which is consumed by airplanes, trucks, buses, and automobiles within public transportation. Each of these transportation modes employs internal combustion engines to convert the petroleum products (gasoline, diesel fuel, etc.) to usable energy.

The purpose of this instructional module is to show you how to conserve energy in the public transportation sector.

TERMINAL PERFORMANCE OBJECTIVE

Upon completion of this instructional module, you will employ various methods to help conserve energy in public transportation. If you obtain a 100% rating on each of the instructional package Pre-Checks, go to the next instructional package. If not, complete each or all instructional packages and obtain an 80% score on the Post-Check.

Achievement of the terminal objective will be accomplished by successfully completing the five instructional packages. Perhaps you already know something about conserving energy in the public transportation sector. If this is true, you may wish to take the Pre-Check to determine the extent of your knowledge. The results of the Pre-Check may be used to diagnose and prescribe the instructional module. If you feel that you do not have any knowledge about conserving energy in the public transportation sector, you may eliminate the Pre-Check and begin the first Instructional Package. The results of your own individual diagnoses and prescription may be recorded below.

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1.	Use of Mass Transportation and Values to Conserve	____	____
IP-2.	Conserving Fuel by Weight Reduction	____	____
IP-3.	The Effect of Lower Speed-Limits on Energy Conservation in the Public Transportation Sector	____	____
IP-4.	Conservation Through Car-Pooling	____	____
IP-5.	Conserving Energy by Design	____	____

PRE-CHECK

ENERGY CONSERVATION IN PUBLIC TRANSPORTATION

DIRECTIONS: Check the answers with the Pre-Check Key. If you miss more than one question per section, you will need to devote time in learning about this area. You may record the learning packag to use by checking the packages on the learning guide.

IP-1. Use of Mass Transportation and Values to Conserve

Circle the following T for True or F for False

T F 1. Mass transit systems do not offer an economical alternative to the private car.

T F 2. A bus fare is higher when compared to the cost of driving alone.

T f 3. Mass transportation is not catching on in the U.S.

T F 4. Most people still want the luxury of their own personalized transit system.

IP-2. Conserving Fuel by Weight Reduction

Multiple Choice: Place the letter of the best answer in the blank.

_____1. Gasoline fuel consumption can be improved approximately 1 kilometer/ 3.785 liters for each ________ removed from the vehicle.

A. 181 kilograms
B. 500 kilograms
C. 250 kilograms
D. 10 kilograms

_____2. In an attempt to reach the fuel consumption guides mandated by the federal government lighter vehicles resulted from:

A. Shorter wheel base only
B. Lighter materials only
C. Both A and B
D. Neither A nor B

_____3. Consumption guides by the federal government state that the fleet average of vehicles must be:

A. 40 mpg in 1980 and 45 mpg by 1985
B. 15 mpg in 1980 and 20 mpg by 1985
C. 10 mpg in 1980 and 30 mpg by 1985
D. 20 mpg in 1980 and 27.5 mpg by 1985

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PRE-CHECK (Continued)

ENERGY CONSERVATION IN PUBLIC TRANSPORTATION

1P-3. The Effect of Lower Speed-Limit on Energy Conservation

_____1. Observing the 55 mph speed limit saves:

A. Fuel only
B. Money only
C. Lives only
D. All of the above

_____2. As your speed increases, so does your car's __________ which in turn increases fuel consumption.

A. Wind resistance
B. Gas Mileage
C. Air Conditioning
D. Electrical Supply

_____3. A careful driver should be able to get at least

A. 15% better mileage than an average driver
B. 20% better mileage than an average driver
C. 90% better mileage than an average driver
D. 30% better mileage than an average driver

_____4. Most cars get about:

A. 10% better mileage at 55 mph than at 70 mph
B. 15% better mileage at 55 mph than at 70 mph
C. 16% better mileage at 55 mph than at 70 mph
D. 21% better mileage at 55 mph than at 70 mph

1P-4. Conservation Through Car-Pooling

Circle the following T for True or F for False

T F 1. Carpools do not make sense.

T F 2. The daily carpooler saves very little on commuting costs, wear and tear on his vehicle and often does not help conserve our precious fuel supplies.

T F 3. Vanpooling is simply a larger, more organized form of carpooling.

T F 4. A vanpool consists of 8 to 11 neighboring employees who commute more than 20 miles to and from work.

T F 5. The national speed was lowered to 50 mph.

T F 6. By carpooling, gasoline consumption dropped approximately 3.4% and highway deaths 17%.

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PRE-CHECK (Continued)

ENERGY CONSERVATION IN PUBLIC TRANSPORTATION

T F 7. If the average passenger load were increased by just one person, the nationwide gasoline savings would be more than 70 barrels of oil per day.

T F 8. People's value and the degree of inconvenience are not primary concerns when considering car-pooling.

IP-5. Conserving Energy by Design

T F 1. Air drag does not absorb a significant part of the power of vehicles.

T F 2. There are many improvements in engines which help to conserve fuel.

T F 3. Some improvements include electronic ignition, precise fuel injection methods, and use of engine design such as diesel, gas turbine, and Stirling engines.

T F 4. On the average, the gasoline engine is 22% to 28% efficient; the diesel engine is 32% to 38% efficient; the gas turbine is 42% to 48% efficient.

T F 5. The Stirling engine design is less efficient than the gasoline, diesel, and gas turbine engines.

T F 6. Technological improvements are needed before the Stirling engine is marketable.

T F 7. Probably the most logical long-range answer to energy conservation in the transportation sector is the electric vehicle.

PRE-CHECK KEY

ENERGY CONSERVATION IN PUBLIC TRANSPORTATION

IP-1. Use of Mass Transportation and Values to Conserve

1. F
2. F
3. T
4. T

IP-2. Conserving Fuel by Weight Reduction

1. A
2. C
3. D

IP-3. The Effect of Lower Speed-Limits on Energy Conservation

1. D
2. A
3. D
4. D

IP-4. Conservation through Car-Pooling

1. F
2. F
3. T
4. T
5. T
6. T
7. T
8. F

IP-5. Conserving Energy by Design

1. F
2. T
3. T
4. T
5. F
6. T
7. T

ENERGY CONSERVATION IN PUBLIC TRANSPORTATION

IP-1. Use of Mass Transportation and Values to Conserve

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. View the important aspects of energy conservation after listening to lectures, watching films, and reading reference materials; thereby maintaining or altering your values so that you will conserve energy.

B. Become familiar with the history of public transportation and the terminology needed to read related materials after participating in classroom discussion.

C. Understand why and how energy can be conserved through public transportation after reading Chapter 12, Energy Conservation in Energy Technology by Anthony E. Schwaller.

RESOURCES

Please listen to the lectures and review the following resources.

Books:

Energy Conservation: Transportation. U.S. Dept. of Energy. Technical Information Center: Oak Ridge, TN, n.d.

Energy Technology:: Sources of Power. Schwaller, Anthony E. Worcester, MA: Davis Publications, Inc., 1980.

Magazines:

"What We're Already Doing to Save Energy." Changing Times, August 1977.

U.S. Department of Health, Education, and Welfare, "President's Energy Message."

Additional resources on the following pages.

REFERENCES

A Manual on User Benefit Analysis of Highway and Bus-Transit Improvements. American Association of State Highway and Transportation Officials, 1977.

Capacity Charts (Nomograph and Procedure). Leish, Jack K. Traffic Institute Northwestern University.

Energy Impact Analysis Resource Information. U.S. DOT, FHWA. June 1976.

Estimating the Effects of Urban Travel Policies. Charles River Associates. For U.S. DOT, April 1976.

Factors Affecting Automobile Fuel Economy. U.S. EPA, 1977.

Guidelines to Reduce Energy Consumption Through Transportation Actions. Voorhees, Alan M. & Associates, Inc. for U.S. DOT, UMTA, May 1974, p. 29, A54-A60, A65.

Handbook for Transportation System Management Planning, Volume 2. Handbook for the Evaluation of Individual Transit-Related TSM Actions. AMV for NCTCOG, August 1977.

Highway Capacity Manual. Highway Research Board, Special Report 87. 1965.

Lexington Signal System Design Study. Technical Memorandum #2, Kimley-Horn and Computran, Inc. for Kentucky DOT and Lexington-Fayette Urban County Government. June 1978, p. 13.

Mobile Source Emission Factors. (For Low Altitude Areas Only.) U.S. EPA, March 1978, Appendix F.

NCHRP Report 187. *Quick-Response Urban Travel Estimation Techniques and Transferable Parameters: User's Guide*. TRB, 1978.

Procedure for Estimating Highway User Costs, Fuel Consumption, and Air Pollution. U.S. DOT/FHWA, March 1980.

Special Report 125: Parking Principles. HRB, 1971, p. 15-16.

Trans-Urban Computer Model (OPGAS). Bloom, Kent. For U.S. DOT/FHWA, April 1973.

Traffic Assignment Manual. U.S. Dept. of Commerce. June 1964, p. V-13, Figure V-9.

Traffic Engineering Handbook. Institute of Traffic Engineers, 1965, p. 413.

REFERENCES (Continued)

Traffic Engineering: Theory and Practice. Pignataro, Louis J. 1973, p. 106-107.

Traffic Engineering. ITE. April 1975. "Application of RUNCOST for Evaluation of a Hybrid Traffic Control System." Howard R. Chapman and J. Edwin Clark, P.E., p. 36-45.

Transportation Energy Efficiency Manual (TEEM). Kimley-Horn and Associates, Inc. For the Florida Governor's Energy Office, March 1981.

Transportation Research Record 546. Regional Bus Transportation. TRB, 1975. "Public Transit Right-of-Way." Bakker, Dr. J.J. p. 13-21.

Transportation Research Record 630. Evaulation of Transportation Operational Improvements. TRB, 1977. "Methodology for Evaluating Bus Activated Signals." Seward, Samuel R. and Robert N. Taube. p. 11-17.

Transportation Research Record 648. Environmental and Conservation Concerns in Transportation: Energy, Noise, and Air Quality. TRB, 1977. "Development of Criteria for Reserving Exclusive Bus Lanes." Miesse, C.C. p. 66-70.

Transportation Research Record 663. Recent Developments in Bus Transportation. TRB, 1978. "The Santa Monic Freeway Diamond Lanes: Evaluation Overview." Billheimer, John W. p. 8-16.

Transportation System Management: An Assessment of Impacts. Alan M. Voorhees & Associates, Inc. for U.S. DOT, UMTA. November 1978, p. 61, 105-125, 57.

Transportation System Management. Special Report 172. National Academy of Sciences, 1977. p. 76, 63, and 47.

Transportation and Traffic Engineering Handbook. ITE, 1976. p. 121-137.

Travel Estimation Procedures for Quick Response to Urban Policy Issues. NCHRP Report 186. For Transportation Research Board. COMSIS Corporation, 1978.

Traveler Response to Transportation System Changes. A Handbook for Transportation Planners. Pratt, Richard H., et al. For U.S. DOT/FHWA. February 1977.

TSM -- An Assessment of Impacts. Wagner and Gilbert. For U.S. DOT, November 1978.

Transportation System Management -- State-of-the-Art. INTERPLAN Corp. for U.S. DOT. February 1977.

REFERENCES (Continued)

User's Manual (TSM) - Energy Conservation Through Transportation Systems Management Actions. Kimley-Horn and Associates/John Hamburg and Associates, for KYDOT. February 1981.

Which Mode Saves the Most Energy? Civil Engineering. ASCE. September 1978.

ACTIVITY

A. Discuss the following question:

What values are at stake when a society is asked to conserve energy?

B. State both short-term and long-term impacts upon these values.

C. Read any materials which depict the history of public transportation.

D. Study the glossary of materials: (1) Listed under resources and (2) portraying the history of public transportation.

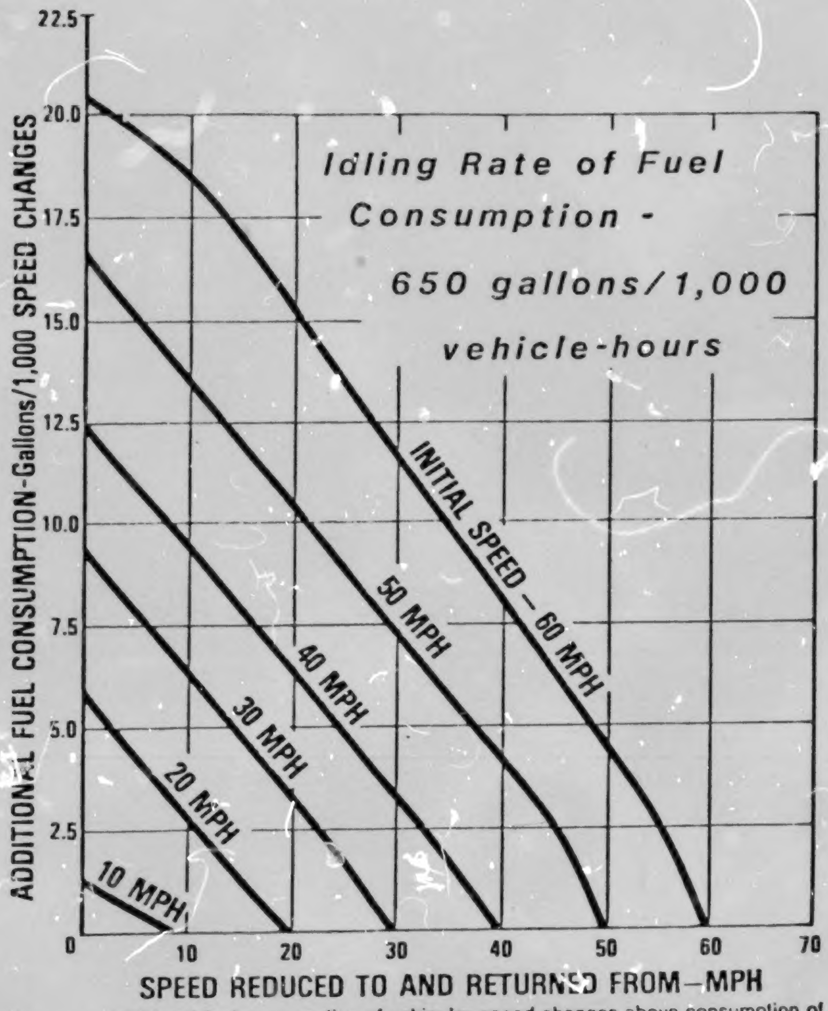
E. Study technical terms which you cannot define or do not understand. Please consult your instructor.

F. Read the references listed under resources, which relate conservation to public transportation.

FEEDBACK

Objective A-C Check:

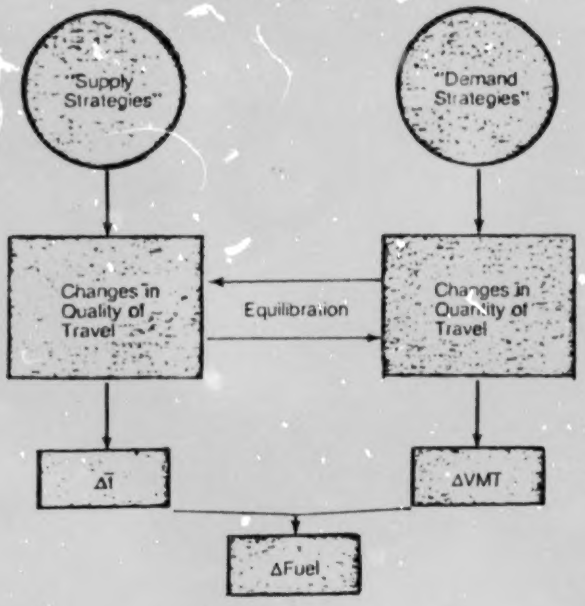
Your reading discussion should have depicted the great amount of energy being consumed in the public transportation sector of society. The degree to which conservation measures are considered will directly influence the number of problems that the United States faces in its future use of energy.



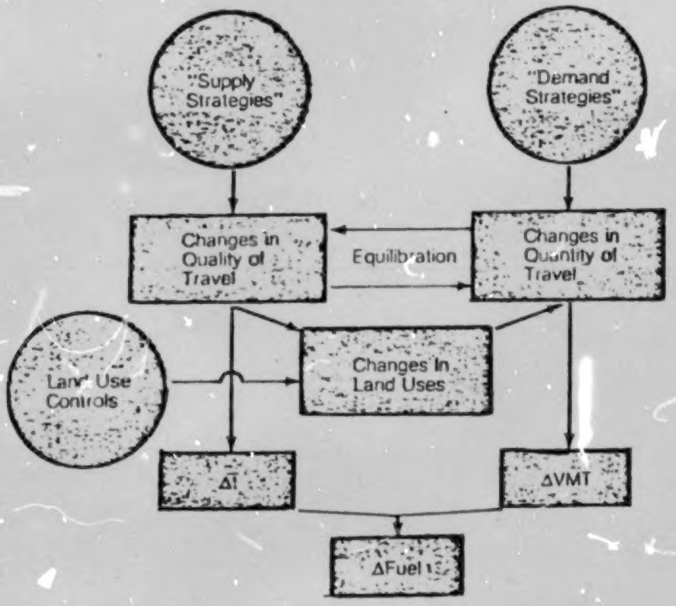
Additional fuel consumption of vehicular speed changes above consumption of continuing at uniform speed (for light-duty vehicles).

Graph Chart IP-1, 1-2

INTERRELATIONSHIPS BETWEEN "SUPPLY" AND DEMAND


"Supply Strategies"
"Demand Strategies"
Changes in Quality of Travel
Equilibration
Changes in Quantity of Travel
Δt̄
ΔVMT
ΔFuel

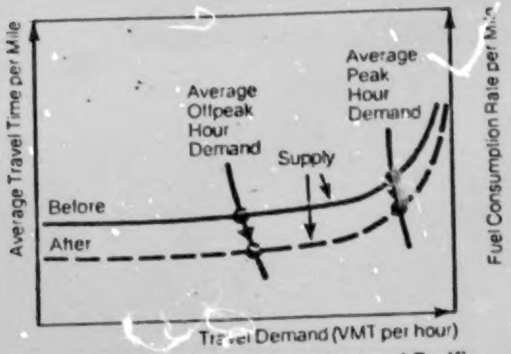
Short-Term Energy Effects of Transportation System Improvements.


"Supply Strategies"
"Demand Strategies"
Changes in Quality of Travel
Equilibration
Changes in Quantity of Travel
Land Use Controls
Changes in Land Uses
Δt̄
ΔVMT
ΔFuel

Long-Term Energy Effects of Transportation System Improvements.

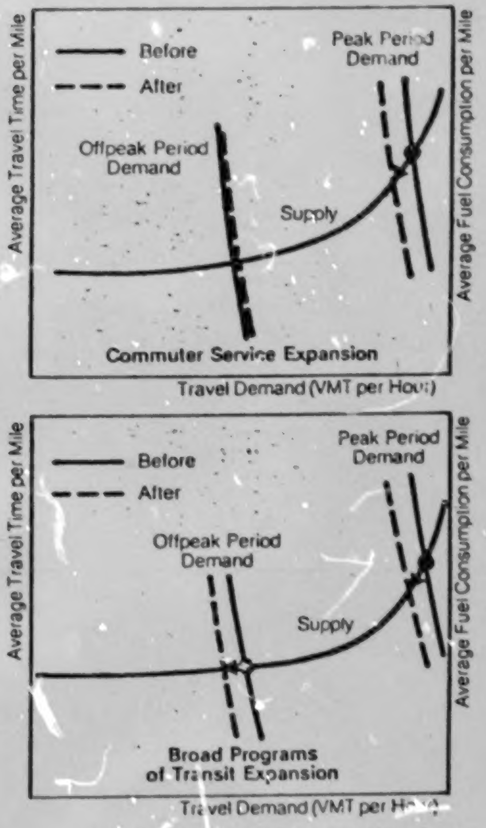
SUPPLY-DEMAND GRAPHS

TRAFFIC SIGNAL SYSTEM IMPROVEMENTS



Supply-Demand Effects of Traffic Signal System Improvements.

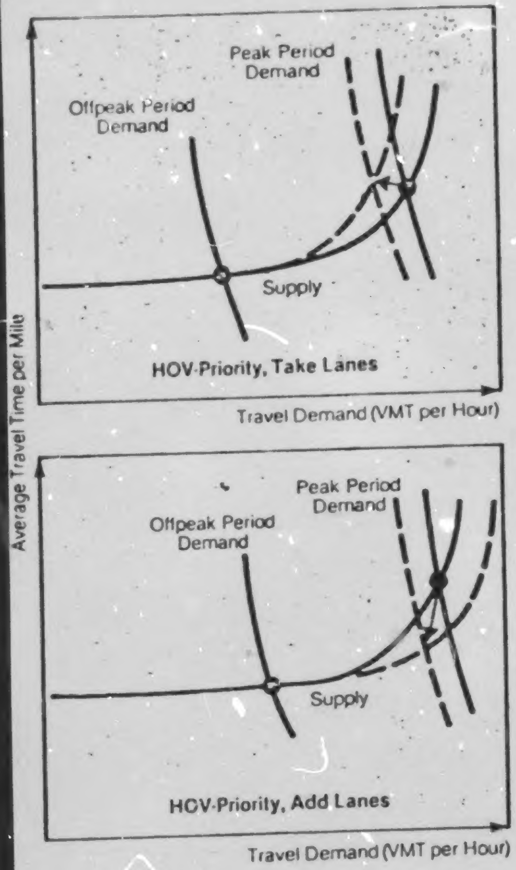
PUBLIC TRANSIT SERVICE EXPANSION



Highway Supply-Demand Effects of Public Transit Service Expansion.

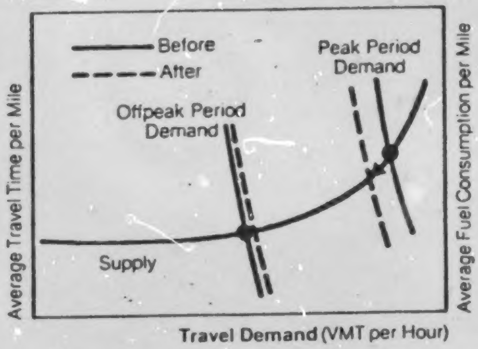
SUPPLY-DEMAND GRAPHS

PRIORITY TREATMENTS FOR HIGH OCCUPANCY VEHICLES



Supply-Demand Effects of HOV Priority Treatments

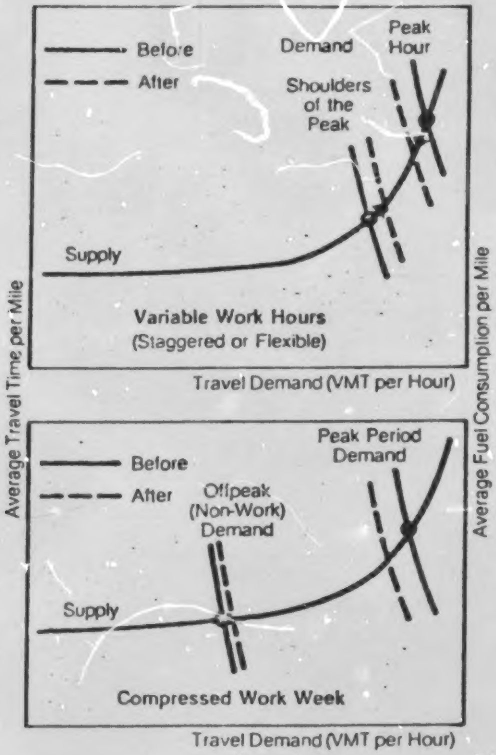
RIDESHARING



Supply-Demand Effects of Ridesharing Expansion Programs

SUPPLY-DEMAND GRAPHS

ALTERNATIVE WORK SCHEDULES



Supply-Demand Effects of Alternative Work Schedules.

ESTABLISHING PRIORITIES FOR IMPLEMENTATION OF VARIOUS TRANSPORTATION SYSTEM MANAGEMENT IMPROVEMENTS

Comparative Evaluation (Using one or more of the following.)

Measure of Evaluation	Qualitative Evaluation	Quantitative or Qualitative Values*
A. Potential for Energy Savings	1. Highly promising	10
	2. Promising	7
	3. Minimal	3
	4. Potentially negative	1
	5. Negative	0
B. Level of Implementation Cost	1. Very low	10.0
	2. Low	7.8
	3. Medium	5.5
	4. High	3.2
	5. Very high	1.0
C. Level of Local Funding Required	1. 0% local	10.0
	2. 1-25% local	8.8
	3. 26-50% local	6.2
	4. 51-75% local	3.8
	5. 76-100% local	1.2
D. Level of Technical Expertise Required	1. In house	10.0
	2. Other local	7.8
	3. Some DOT	5.5
	4. Extensive DOT	3.2
	5. Outside expert	1.0
E. Level of Population Impacted	1. Very high	10.0
	2. High	7.8
	3. Medium	5.5
	4. Low	3.2
	5. Very low	1.0

*Value 10.0 represents the "best" condition for a local area.

From the above, or some locally determined variation of the above, relative values can be estimated to rank any number of transportation system improvements. This ranking will allow local areas to establish priorities and justification for improvements and to better select improvements for implementation.

ENERGY CONSERVATION IN PUBLIC TRANSPORTATION

IP-2. Conserving Fuel by Weight Reduction

OBJECTIVE

Upon completion of this instructional package, you will be able to:

A. Show how weight reduction on vehicles lessens energy consumption after studying the resources provided below.

RESOURCES

Books:

College Physics. Miller, Franklin. New York: Harcourt, Brace, and World, Inc., 1967.

Energy Technology Sources of Power. Schwaller, Anthony E. Worcester, MA: Davis Publications, Inc., 1980.

Materials Needed:

Two (2) automobiles of the same make, model, engine size, etc., and gasoline.

ACTIVITY

A. Put equal amounts of fuel in each vehicle. Place 1000 lbs. (including the driver) in one vehicle and 200 lbs. (including the driver) in the other. Drive each car at the same speed and over the same highway. Record the mileage for each vehicle.

B. Analyze the data and report your findings (in written form) as they relate to couserving by reducing vehiclular weight.

FEEDBACK

Objective A Check:

Your findings should have indicated that excess weight in public transportation wastes fuel.

ENERGY CONSERVATION IN PUBLIC TRANSPORTATION

IP-3. The Effort of Lower Speed Limit on Energy Conservation in the Public Transportation Sector

OBJECTIVE

Upon completion of this instructional package, you will be able to:

A. Demonstrate how the average passenger car conserves more energy at 55 mph than a vehicle at 65 mph when given the resources provided below.

RESOURCES

Books:

Automobile Mechanics. W.H. Crouse. NY: McGraw-Hill Book Company, 1970.

College Physics. F. Miller. NY: Harcourt, Brace and World, Inc., 1967.

Additional Resources:

Materials and Person needed: Policeman, Police car, Gasoline.

Information on Driver Efficiency Program, IP-3, 1-1 through 1-38.

ACTIVITY

A. Have a policeman drive (after the engine has normalized) as far as one quart of fuel will allow him at 55 mph. Then have him drive as far as one quart of fuel will allow him at 65 mph.

B. Analyze the data and report your findings as they relate to conservation by lowering speed from 55 mph to 65 mph.

FEEDBACK

Objective A Check:

Your findings from Activities A and B should have indicated that a vehicle is more efficient at 55 mph than at 65 mph.

RESOURCE MATERIALS
DRIVER EFFICIENCY PROGRAM

Please send me the following:

Film

________ "Running on Empty" (30 minutes)
________ Short Term Loan from DOE Library (Free)
or
You may order the film from:

Capitol Film Laboratories, Inc.
470 L Street, SW
Washington, DC 20024
(202) 347-1717

Slide Show: Driver Efficiency

________ Loan copy of slide show with written narration
________ Loan copy of slide show with taped narration

Free Pamphlets: Please note the quantity desired:

________ "How to Save Gasoline and Money"
________ "1980 Gas Mileage Guide"
________ "Gas Savers Kit," only a single copy is available
________ "Driver Efficiency Newsletter" (published quarterly)

NOTE: All the DOE materials may be reproduced, copied, and modified freely if they are redistributed without profit.

OPTIONAL EQUIPMENT (continued)

COLOR CASSETTE VIDEO TAPE RECORDER/PLAYER	Good quality, heavy duty 1/2 inch or 3/4 inch color cassette VTR player. One color cassette VTR/player per program.
COLOR TV MONITOR	Good quality 19" color TV monitor or TV set with adaptor for cassette VTR/player. Should have head set (ear phone) adaptor. Size of monitor may vary depending on condition and use of monitor. One color TV monitor per program.
3M SOUND-ON-SLIDE PROJECTOR	At least one 3M Sound-on-Slide Projector may be needed if the individualized program format is selected. An alternate to the sound-on-slide system is the 35 mm slide projector and cassette tape recorder/player combination.
HEAD SETS (EAR PHONES)	Good quality head sets that are compatible with the 16 mm film projector, 35 mm slide projector, cassette tape recorder/player, TV monitor and 3M sound-on-slide projector. Adaptors may be needed to match the above available equipment. The number of head sets needed is dependent on the equipment available. At least one head set should be available for each piece of equipment. Head sets will probably be needed only if the individualized program format is selected.

MATERIALS

DRIVEC Slide Series	35 mm slides dealing with different areas of fuel efficient driving (approximately 225 slides). Available from: Center for Safety and Driver Education Appalachian State University Boone, North Carolina 28608 (704) 262-3143
RUNNING ON EMPTY film	16 mm sound, color film dealing with fuel efficient driving techniques. Available from: Capitol Films 470 East Southwest Washington, DC 20024 (202) 347-1717 (800) 424-5188 $143.00 ($125 m)

MATERIALS (continued)

"16 Steps to Conserve Energy on N.C. Highways" -- North Carolina Energy Division
P.O. Box 25249, Raleigh, NC 27611

"Eleven Simple Ways to get the most out of the gas you buy" -- Gulf Oil Corporation, 1025 Connecticut Avenue, NW Washington, DC 20036

Shell Answer Book # 1 - The Early Warning Book
3 - The Gasoline Mileage Book
4 - The Car Buying & Selling Book
5 - The 100,000 Mile Book
# 6 - The Rush Hour Book
# 8 - The Car Repair Shopping Book
#14 - The Driving Skills Book
#17 - The Self Service Book
#18 - The Tune-Up Book
#19 - The Gasoline Book
#23 - The How Your Car Works Book
#24 - The More Miles for Your Money Book
Shell Answer Books, P.O. Box 61609, Houston, Texas 77208

"Don't be an energy hog - A primer on saving fuel...and saving money"
Mobil Oil Corporation, 150 East 42 Street, New York, N.Y. 10017

"Gas Watchers Guide" -- American Automobile Association, 8111 Gatehouse Road, Falls Church, VA 20047

"Shopping for that Fuel Economy Car" -- Public Affairs Committee, Society of Automotive Engineers, Inc. 400 Commonwealth Drive, Warrendale, Pennsylvania 1509

"Energy Conservation in Transportation" --Programs of the U.S. Department of Transportation, Washington, DC 20590

ADDITIONAL ADDRESSES FOR EQUIPMENT & MATERIALS

Featherfoot - American Institute of Driving Efficiency, 892 Rice Street,
St. Paul, Minn. 55117 -

Floscan Instruments Co., 3016 N.E. Blakely, Seattle, WA 98105
(206) 524-0625

Halda Tripmaster, Vilem B. Haan Inc., 7551 Coldwater Canyon, North Hollywood,
CA 91605 (213) 982-1050

Marshall Town, Vacuum Gauge, Marshall Town, IA (515) 752-9295

Matt Marshall & Company, Route 7, Box 170, Greensboro, NC 27407
(919) 292-8477

MATERIALS (continued)

WHO CARES? film	Fuel efficient driving techniques with emphasis on the operation of school buses. Available from: Visucom Productions, Inc. $400\text{-}475^{00}$ P.O. Box 5472 Redwood City, California 94063 (415) 364-5566
THE DRIVE FOR CONSERVATION Sound filmstrip	A part of the Atlantic Richfield Co. "The Drive for Conservation" Educational Program. The filmstrip deals with fuel efficient driving techniques. The program also includes a "Driver Education Booklet" and a one page "tip sheet" on fuel efficient driving. Available from: Atlantic Richfield Co. [MAYBE JUST FOR ASKING] Public Affairs, Room 1619 P.O. Box 2679 Terminal Annex Los Angeles, California 90061
"FEATHERFOOT" Program $\$300^{00}$	A program dealing with fuel efficient driving techniques. The program includes: a 16 mm film, information sheets on driving efficiency factors, a "Driving Efficiency Quotient" test, a "Dial your MPG" card, and a MPG Record for your vehicle.
YOUR DRIVEC CAR CARE RECORD BOOKLET***	A booklet that can help a person keep a more accurate account of the operational costs of the vehicle. Available from:

Assorted pamphlets dealing with fuel efficient driving***

"Common Sense in Buying a New Car" -- Office of Public and Consumer Affairs U.S. Department of Transportation, Washington, DC 20590

"How to Save Gasoline...and Money" -- U.S. Department of Energy, Office of Public Affairs, Washington, DC 20585

"Unleaded Gas...The Way To Go" -- U.S. Environmental Protection Agency, Washington, DC 20460

"The Road to Conservation" -- The Drive for Conservation, P.O. Box 30181, Los Angeles, California 90030

***Materials that should be given to students taking the DRIVEC Training Program

ADD UP YOUR SAVINGS. STEP BY STEP, GALLON AFTER GALLON, TANKFUL AFTER TANKFUL, YEAR AFTER YEAR

If you take all of the steps in this column		It's the same as saving about this much on each gallon of gasoline* If gas Cost $1.20
How to Drive More Efficiently		
Warm engine correctly		
Drive at a moderate speed		
Accelerate briskly and steadily		
Anticipate what's ahead—leave buffer around your car		
Flow smoothly through traffic	altogther,	6¢
How to Plan Your Trips		
Rideshare to work with a friend		
Plan family errands		
combine trips		
use the telephone and mail		
ride with others	altogether,	3¢
Plan social and recreational trips		
combine trips		
rideshare	altogether,	3¢
How to Care for Your Car		
Inflate tires to highest recommended pressure		3¢
Select high-mileage oil		3¢
Get tune-up and adjustments when needed		4¢
How to Choose Your Next Car and Tire		
Buy radial tires		3¢
Replace your present car with another that gets 10 mpg more than your present one		21¢
	You can save:	56¢

*These savings are slightly smaller than the individual figures given in the text because each amount shown here is based on the assumption that you take *all* of the steps.

SOURCE: Transportation Programs, Conservation and Solar Applications, U.S. Department of Energy, Washington, D.C. 20545.

REVIEW OF RESOURCES IN BRIEF

The Road to Conservation - Atlantic Richfield Company

A very good attractive booklet, easy to understand and summarized. It covers every tip to use toward getting better gasoline performance. This would be a very useful book to have in bulk so that your students could benefit and put to practice these suggestions to see how they work.

Summary

Excellent, however, on a personal note I was upset when I attended a session with an ARCO representative. I asked to test him about ARCO's involvement with ADTSEA and he said that he wasn't aware of any involvement and said, "little if any". So I wonder how they looked upon our assistance. I know in the filmstrip it has a frame of our emblem but in the slide show at South Dakota there was no mention of our assistance or in the booklet anywhere. I was told of our involvement through Mr. J.B. Angelo Crowe, and Dr. Donald Smith present president. If we deserve recognition then I'd like to see that we get it as a matter of public relations with the public.

Contact

Atlantic Richfield Company
515 South Flower Street
Los Angeles, California 90071

REVIEW OF RESOURCES IN BRIEF

Champion Spark Plug Literature

17. 1. Champion Ten step tun-up guide
    2. Used plugs tell a story + poster + chart
    3. Champions guide to an easy car tune-up
    4. Plant tour
    5. Constructive features of the spark plug in post form
    6. Automotive service manual
    7. Engine tune-up chart
    8. Master application catalog

1. Short easy tips on how to perform a simple tune-up or how one is performed. The ten steps are as follows:

    1. Remove the air cleaner
    2. Remove the spark plugs
    3. Make a cylinder compression check
    4. Check the distributor cap and rotar
    5. Remove the ignition parts
    5. If you adjust your points with a tech/dwell tester
    7. Gapping and installing champion spark plugs
    8. Adjust timing
    9. Adjust the carburetor
    10. Wrapping up.

This pamphlet gives step by step procedures.

Summary

Excellent

2. A sticker that can go in an area where you work on your car which gives a description for various problems in plugs, very helpful to the beginning mechanic. Also a larger poster of the same and a chart which helps you diagnose and apply a solution.

Summary

Excellent

3. This guide is equipped with all the tools, information, and charts you will need in order to perform your own tune-up. Illustrations make it easy to understand and allow you to save money on labor cost.

Summary

Very good

4. This is a booklet of their plant located in Toledo/Detroit and tells of the different assembly areas and departments. It gives you a good idea of how much trouble champion goes through to produce one plug.

Summary

Informative

5. This poster consists of the construction features, basic conventional ignition system, and the basic electronic ignition system. This gives someone the fundamentals of the parts of these systems and an idea of where they are located and what they look like.

6. This service manual gives information on spark plugs, tune-up benefits, relations to ignition systems, analysis of plugs and a more detailed idea of how to perform a tune-up and what to look out for, and the equipment that is available through your champion wholesaler.

Summary

Tells everything except the cost of equipment.

7. This tune-up chart allows you to find the car you're working on by make/model/year/engine size and other serviceable information.

Summary

Not too simple for the common person.

8. This is a simple chart with abbreviations explained at the beginning of the book. It allows you to find your car and explains the proper gap, size plug, for the appropriate car and size engine.

Summary

Simpler than 7.

Contact

Champion Spark Plug Co.
Box 910
Toledo, Ohio 43661

REVIEW OF RESOURCES IN [illegible]

Via Dr. Frank Brouillet - Bill F. Hiblar
Superintendent of Public Instruction
Olympia, Washington 98504

Pamphlets:

1. Easy Ways to Cut Your Transportation Costs!

This small card gives excellent tips to help you stretch your gasoline dollars. Proper tuning, correct tire pressure, bad driving habits, planning ahead, less stops and gas, and driving as little as possible.

Summary

Excellent - If it were smaller, it could be carried with you.

2. Don't Be Fuelish - 30 tips for the motorist to use in everyday driving and in buying new cars.

Summary

Excellent for a discussion emphasis.

3. 1978 Gas Mileage Guide - Same as 1980 guide with cars, sizes, models, miles per gallon engine size.

Summary

Useful in comparing gas economy cars and in buying them.

4. The Automobile - It's Driving Us to Think - Very useful with a questionnaire included for feedback on the booklet and of transportation of the future.

Summary

Excellent - it gives you the feeling that you can have an active part in improving our transportation in the future.

Contact

1. Washington State Energy Office
Lawrence B. Bradley, Director
[illegible] East Union [illegible]
Olympia, Washington 98504

2. Energy Conservation and Environment
Federal Energy [illegible]
Washington, D.C. [illegible]

Spokane Branch Office - 509-456-6[illegible]08
Seattle Branch Office - 206-464-5[illegible]

3. Single copies: Fuel Economy
Pueblo, Colorado 81009

Bulk copies: US Department of Energy
Fuel Economy Distribution
Office of Administrative Services
Washington, DC 20585

4. Congress of the United States
Office of Technology Assessment
Washington, DC 20510

BRIEF REVIEW OF RESOURCES

1. 55 - Some Tough Arguments About Trucks and the NMSL
2. 55 mph - The Texas 55 mph Safer Highways Campaign
3. 55 mph - Saves lives, gasoline, and money
4. 55 saves

Texas Safety Association 2, 3, 4

1. This pamphlet gives an argument for the rising of the 55 mph, and responses to their aguments by the Department of Transportation. It seems truckers are the largest advocaters of the 55 mph law and the Department shows them facts behind their responses for those who wish to argue.

Summary

Very informative (what does NMSL stand for)

2. Texas gives information and facts to support the 55 mph law and shows records and graphs to prove that 55 is better then 70.

Summary

I wish their address was available on the pamphlet. Very good and other state associations should follow suit.

3. Very much the same information with a more impressive front cover. Summary as before.

4. This gives the person a chance to measure their present gas mileage and compare and gives an easy formula as well as facts.

Summary

Very much like the one offered by HUFSM

Contact

Texas Safety Association
Texas Office of Traffic Safety
State Department of Highway and Public Transportation
Austin, Texas 78701

6

REVIEW OF RESOURCE MATERIALS IN BRIEF

Kit - Gas Savers - Department of Energy

This would be an excellent program to encourage State Driver Education Associations to get involved with. The Kit consits of many suggestions on such topics as Routes to Fuel Economy, Planning Techniques, Driving Skills, Vehicle Selection, and Maintenance. The Kit also includes an excellent booklet entitled Vanpool Implementation Handbook, which shows someone the advantages of van-pooling and how to go about constructing a program of their own. It also has a program of teach-ins which for this year are mostly on the western portion of the United States. On the blue-sheet which describes this program is an address where possibly could be made suggestions of future localities for 1981.

Other guides include 1980 Gas Mileage Guide which tells by cars size, model, and make, estimated miles per gallon, average annual fuel cost, engine, transmission, fuel system, and body type. Useful to those thinking of buying a car. Also a small brochure on vanpooling, and another on How to Save Gasoline...and money, and a bumper sticker as well. Also included is a Kit which can be used over and over again with reminders for under the hood checks, put in places to remind you.

Summary

I find the Kit very useful and would like to see it put to use. In the Vanpool Implementation Handbook are personnel listed by state, as to whom to contact for help. North Carolina has no one listed yet.

Contact

Cynthia McLaughlin
Darrell Beachem
Irv Dubinsky
Driver Efficiency Program
CS-030 (Resource Materials)
Department of Energy
Washington, DC 20585

1-800-424-9043

REVIEW OF MATERIALS IN BRIEF

Get More Missouri Per Gallon
Money Saving tips for Missouri motorists

With interesting illustrations this pamphlet would appeal to almost everyone. Charts and graphs show how you can compute your own mileage, and apply some of the tips that are available such as proper tire inflation. With this style of presentation, there would be few people who would stop reading this pamphlet once they started.

Summary

Excellent way to put a point across.

Contact

Missouri Department of Natural Resources
Box 1309
Jefferson City, Missouri 65102

1-800-392-0717

REVIEW OF RESOURCE MATERIAL

Some useful facts on energy - Gulf Oil Corporation - January, 1980

This colorful booklet consists of areas in energy, petroleum, natural gas, coal, nuclear, transportation, and financial, uses, and charts and graphs, but it needs to be available at the service stations to get to the public.

Summary

Good

Contact

Persons in our area are available in the rear of the booklet

Michael M. Kumpf
Gulf Oil Corporation
P.O. Box 7245
Station C
Atlanta, Georgia 30357

404-897-7738

OR

Keith F. Anderson
Gulf Oil Corporation
P.O. Box 989
Morgantown, WV 26505

304-296-4179

Also included is a pamphlet, eleven simple ways to get the most out of the gas you buy. This would be very useful if it were openly available in service stations and advertised. Also included is a reprint from Petroleum Today 1973/two entitled That Amazing Maze A Refinery by W. Harrison Brewer explains a simple and comical sense in explaining how fuel is made from crude oil. Included are also two issues of Gulf Dealer News a magazine for dealers March-April issue and May-June issue explaining the new Gulf super unleaded gasoline.

Contact

Gulf Dealer News
P.O. Box 1563
Houston, Texas 77001

for Gulf Dealers Magazine

BRIEF REVIEW OF RESOURCES

How to save gasoline...and money

Along the line of the brochure produced by the Department of Education with fuel conserving tips and ride sharing as well as low cost care of your car. Suggestion of "Running on Empty" film from the USDOE and they at the Ohio Department have a toll free number for information on all forms of energy - 1-800-282-9234

Summary

Same as DOE's version

free loan films

Contact

Ohio Department of Energy
30 E. Broad Street
Columbus, Ohio 43215

BRIEF REVIEW OF RESOURCES

Don't Be An Energy Hog
a primer on saving fuel...and saving money
Mobil Oil Corporation

This booklet instantly by the illustration on the outside gives you an idea of what this booklet is all about. Included inside are 12 ways to save energy and they have a picture with an explanation. The pictures are satyrical and rather than have captions, leave it up to you to decide on how you can avoid these unpleasantries.

Contact

Mobil Oil Corporation
150 East 42nd Street
New York, NY 10017

BRIEF REVIEW OF RESOURCES

Shell Answer Books - The Energy Book

Shell is a leader in energy saving tips and is perhaps the most famous for their 24 series. They ship them free, at no charge and the information that can be received can be priceless.

The Energy Book is in the process of being updated on pages 3 and 8 and tells many tips as well as where will our fuels come in the future.

Summary

Shell will send these materials by boxes if requested as long as you explain what you need them for, how many of each and which ones.

Contact

H.B. Deviney
Shell Oil Company
One Shell Plaza
P.O. Box 2463
Houston, Texas 77001

REVIEW OF RESOURCES IN BRIEF

16 Steps To Conserve On Our Highways

North Carolina Department of Public Instruction's Division of Health, Safety, and Physical Education and Division of Science Education, in cooperation with the North Carolina Department of Commerce's Energy Division.

This booklet is a sincere effort to give you fact based solutions to combat the energy crisis. Each unit has a question review over what is to be read in each chapter and a further study section which allows you to put these tips or suggestions into action. The table of contents is valuable in finding just what you are looking for and illustrations are good to keep interest. Abbreviations are explained at the beginning of the booklet and references are available at the end.

Summary

Very good, however, more illustrations could be used to encourage amusement along with reading.

Contact

North Carolina Department of Public Instruction Division of Health, Safety, and Physical Education.

REVIEW OF RESOURCES IN BRIEF

1. Tips for Energy Savers
2. 1980 Gas Mileage Guide
3. Gas Savers (2)

1. Tips for Energy Savers is for energy conservation for the home dealing with electrical appliances as well as on the road means.

Summary

Tells of ways to cut down on electrical cost and use electrical and guels of other means more wisely.

2. 1980 Gas Mileage Guide - Review number 1 as written before telling car make, size, fuel efficiency, engine size, and miles per gallon.

3. Gas Savers A - Consisting of DOE Facts, tips on routes to Fuel Economy, Planning Techniques, Driving Skills, Vehicle Selection, and Maintenance. Other areas of How to save gasoline...andmoney, vanpooling and a Kit for checking your car properly for best fuel efficiency - not as impressive as first one.

Gas Savers B - Energy Efficiency - Routes to Fuel Economy, Voluntary Truck and Bus Fuel Economy Improvement Program, Starting a Driver owned and operated vanpool, 1980 mpg ratings, How to save gasoline and money, bumper sticker and Kit for checking fuel economy - very good, plenty of areas are covered.

1. US Department of Energy
Editorial Services, 86-031
Office of Public Affairs
Washington, DC 20585

2. Fuel Economy Distribution
Technical Information Center
Department of Energy
P.O. Box 62
Oak Ridge, Tennessee 37830

3. Gas Savers
US Department of Energy
Conservation and Solar Applications
Office of Transportation Programs
(A)(B) Energy Efficiency
[illegible]
[illegible]
CS-830 (Resource Materials)
Department of Energy
Washington, DC 20585

1-800-424-[illegible]

REVIEW OF [illegible] IN BRIEF

You and Your Driving

Tips for safe driving, improving driving skills, maintaining your car, saving gasoline. This is Exxon's attempt to educate the public in a manner of instant feedback and areas of interest and seasonal care of the vehicle. Students found this booklet quite interesting and useful in our school curriculum.

Summary

Very good. I wish that it was available at Exxon Service Stations.

Contact

Published by Exxon Company, USA
Distributed as a Public Service By:

National Association of Women Highway Safety Leaders, Inc.
7206 Robinhood Drive, Upper Marlboro, Maryland 20870

Mrs Frank Umbah - Our contact from Waynesboro
1796 Meadowdale Works with Georgia Safety Council
Atlanta, Georgia 30309

BRIEF REVIEW OF RESOURCE MATERIAL

Factors Affecting Automotive Fuel Economy, October 1976

United States Environmental Protection Agency.

This is the third EPA report on the subject of automobile fuel economy. The two previous reports were published in November 1972 and October 1973.

The previous EPA reports have been studied and commented upon by other government agencies, the Congress, State and local governments, private citizens, fleet operators, motor vehicle manufacturers, and fuel producers. This report is intended for the same broad audience. This report contains new information on emission controls and tampering, and the average fuel economy of the 1975 cars. It also includes information on driving patterns and their effect on fuel economy. Thus it should aid drivers as well as car buyers in making choices which can affect their gas mileage.

Summary

Very informative with suggestions as to what we can do to help our fuel and emission problems.

Contact

Michael Walsh/Gregory Dana
Deputy Asst Administrator for Mobile Source Air Pollution Control
U.S.E.P.A.
Washington, DC 20460

1-202-755-0596

Information IP-3, 1-22

BRIEF REVIEW OF RESOURCE MATERIAL

55--How to Live With It
by General Fred W. Vetter, Jr. - July 21-24, 1980

I was able to attend the National Student Safety Program at Black Hills State College in Separfish, South Dakota to hear General Vetter. I found his information shocking, astonishing, and informative on the great advantages of the 55 mph law and what it has accomplished in the years of its enforcement. His presentation of our theme, Pledge 55 with what he had to say, brought about a dramatic response that driving 55 mph is the best thing that we can do to combat the energy crisis.

Summary

Excellent presentation

Contact

Department of Transportation
National Highway Traffic Safety Administration
Washington, DC 20590

or

Fred W. Vetter, Jr.
Fed/States Coordinator 55 mph
2201 Fed Bldg 300 S. New St.
Dover, DE 19901

REVIEW OF RESOURCE MATERIAL IN BRIEF

The Highway Fact Book - Highway Users Federation

This booklet gives an update on how our transportation system stacks up nationally. With twenty-four different areas of interest, especially on page 23 entitled 16. What are the relative cost of the various modes of urban travel? It answers the question that van-pooling with eight occupants would cost 5.4 cents per mile as compared to an automobile with one occupant would cost 37.1 cents per mile. Other examples of the twenty-four topics are, What is the role of the Federal Government in highway development?, How are our roadways organized?, How has air quality improved?, and many others.

Also included in the packet that was sent is a pamphlet on Supplementary Energy Sources made by the American Petroleum Institute which gives long term, expensive solutions to our energy crunch, it also gives facts behind each solution of Coal, Gas from Coal, Oil from Coal, Oil Shale, Tar Sands, Geothermal, Nuclear, Solar, Tide and Ocean,and Wind Power.

Also included was a booklet on Vanpool Commuting as far as Regulatory and Legal Aspects, funded by HUFSM and published by The National Center for Administrative Justice. This booklet spells out the regulations and proper legalities involved in vanpooling. Included in another pamphlet produced by the National Capital Area Transportation Federation entitled Transportation Goals are special areas of emphasis stressed by Neil E. Goldschmidt, U.S. Secretary of Transportation on 9-5-79.

Summary

[illegible] problems on energy.

such areas as, Better Administration, Financing, Parking, Energy, Right Turn on Red, Traffic Safety, Better and Safer Traffic Flow, Recommendations, and Suggested Corrective Improvements, which is a program to: Increase Jobs, Boost Business, Conserve Energy, Reduce Pollution, and increase Traffic Flow.

There is also a guide reprint entitled: 55 m.p.h. What Happened to Speed Travel. Accidents and Fuel when the Nation's Motorist Slowed Down... published by HUFSM which answers this question. Finally included are two other publications of HUFSM - Facts on Vital Issues and Gas-Saving Do's and Dont's.

Summary

I find the materials very informative and useful, especially the Gas-Saving Do's and Don'ts and The Highway Fact Book as well as the reprint What Happened to Speed, Travel, Accidents and Fuel When the Nation's Motorist Slowed Down of which I wish they would make an update since 1974.

Contact

Bob Calvin
HUFSM
1776 Massachusetts Avenue, NW
Washington, DC 20036

1-202-857-1200

BEST COPY AVAILABLE

BRIEF REVIEW OF RESOURCES

Driver Education Curriculum Guide
Ohio Department of Education
Division of School Finance
Driver Education Section

Attractive outer cover with state seal and colors. This is an excellent six lesson program with suggestions and filmstrip done in a truly professional manner. This would aid the instructor on what to stress as far as fuel-economy and yet lets the student see with audio-visual effects that fuel economy is an important factor in today's world economics. With self test this program is effective in instant feedback and creates a learning experience for the student.

Summary

Excellent filmstrip and professional program.

The Driver Education Energy Conservation
Larry L. Cathell
State of Ohio Driver Education Section
Columbus, Ohio 43215

BEST COPY AVAILABLE

REVIEW OF RESOURCES IN BRIEF

Highway Safety Highlights - Vol. 13 No. 10 June 1980

This organization has a mailing list of which I am on and this particular monthly issue has publications for sale in a various number of areas in safety. Such areas a child restraints, bicycles, mopeds, motorcycles, energy crisis and highway safety material are for sale.

Summary

Very useful and the advantages of being on the mailing list give you the most up-to-date information in their research studies.

Contact

Theresa E. Hill
Publication Manager's Assistant
The University of North Carolina
Highway Safety Research Center
South Campus
CTP197-A
Chapel Hill, North Carolina 27514

919-933-2202

BEST COPY AVAILABLE

BRIEF REVIEW OF RESOURCE MATERIALS

Energy Conservation Education For Oklahoma Drivers

Tape and Guide Booklet.

This audible and inaudible program along with the guide on how to teach the program is an excellent way to communicate to everyone the importance of Energy Efficient Driving. It gives reasons why we should be concerned with fuel conservation and also gives ways in which to conserve fuel. The booklet is designed as an introduction and gives step by step frames from the filmstrip/tape series so that the teacher may give notes to be tested on later.

Summary

Professionally done with background music which appeals to listeners.

Contact

Dr. Milton Rhoads
208 Poultry Science,
Oklahoma State University,
Stillwater, Oklahoma 74078

How to Save Gasoline and Money as before.

BEST COPY AVAILABLE

Information IP-3, 1-28

REVIEW OF RESOURCE MATERIALS IN BRIEF

Packet 1 - North Dakota Energy Conservation (Driver Education)

Packet 2 - North Dakota Energy Conservation

Packet 1 - A guide consisting of activities and film suggestions with a test in conclusion. Included are facts and lesson plan suggestions as to what should be covered. Also included are 30 tips in large illustrative forms on how to conserve fuel and other gas saving tips. This is put together in cooperation of the governor's office on highway safety. Included is a pamphlet on myths and facts about the 55 m.p.h. controversy. Some Department of Energy brochures, the mpg creed and North Dakota Traffic Trends between 1969-1979. These would be excellent teaching aids to introduce in a learning environment.

Packet 2 - This guide concerns mostly with School Bus Conservation of Fuel. This gives a guide of fuel conserving tips and course outline

Saving School Bus Fuel - Dept. of Transportation

Summary

A good basic guide and tool to give people a basic understanding in vehicle conservation of fuel and a special section on school bus economy.

Contact

Clay Dunlap
Energy Specialist Management
Capital Grounds
Department of Public Instruction

Rolland Larson
Director of Transportation

Brian Larson
Director of Driver Education

Governor's Energy Management Office
1533 North 12th Street
Capital Grounds
Bismarck, ND 58501

701-224-2250

BEST COPY AVAILABLE

REVIEW OF RE[illegible] MATERIALS IN BRIEF

Thinking About Energy - Secondary Studies Guide State of Delaware

This is also a well developed guide for energy with lesson plans and activities. The learner activities put the daily lesson to work and allow the students to discover for themselves. It covers not only energy conservation, but all areas of energy and related subjects and explains on a students terms about geothermal, oil shale, and others. It is also decorated with illustrations to keep it interesting for the student and instructor.

Summary

A good guide to use in the teaching of energy conservation with some humorous illustrations.

Contact

John C. Cairns
Department of Public Instruction
Townsend Building
Dover, Delaware 19901

BEST COPY AVAILABLE

REVIEW OF RESOURCES IN BRIEF

1P-3, 1-30

Shopping for that Fuel Economy Car

This pamphlet gives to the consumer the information they need for buying their new fuel economy car. It has several checklist and questions that will help the individual narrow down the qualities of what they are looking for in a fuel economy car.

Summary

Excellent for the person who wants to figure out the most fuel-efficient and practical car as far as room is concerned.

Contact

Ray Morris
Society of Automotive Engineers, Inc.
400 Commonwealth Drive
Warrendale, Pennsylvania 15096

REVIEW OF RESOURCE MATERIALS IN BRIEF

Common Sense in Buying a New Car

This booklet would be very useful to the person about to buy a new car and the proper way to go about purchasing a vehicle. Headlines as: How not to buy a new car, The right way to buy your new car, Pursuing auto problems...If you have them, Where to take your complaints. These should aid anyone to make their best decision and would be to their advantage to read this guide before purchasing their next vehicle.

Summary

Very informative and should be openly available to the public before they purchase any vehicle.

Contact

[illegible] and Consumer Affairs
US Department of Transportation
Washington, DC 20590

BEST COPY AVAILABLE

REVIEW OF RESOURCE MATERIALS

1. Consumer Tire Guide
2. News
   Tire Industry Safety Council

1. This is an excellent booklet on how to properly care for your tires so that you will get the most wear from them you can get, and better fuel economy. It compares the different kinds of tires and recommendations.

Summary

ADTSEA along with others cooperated with TISC to put the publication together.

2. Three news articles: 1. Proper Tire Pressure Gives Both Fuel Savings and Safety

The following report gives facts to back up this report.

2. Gain 300 Miles by Checking Tires. This would be worthwhile to anyone who doesn't want to pay for that $300.00 at the gas pump.

3. American-Made P-Metric Tires Save Gas. This states that higher inflation in these tires by 3 pounds more than recommended could add to better gas mileage, but never to exceed the maximum molded on the sidewall on a P-metic which is 35 psi.

Contact

Tire Industry Safety Council
Suite 766
National Press Building
Washington, DC 20045

202-783-1022

BRIEF REVIEW OF RESOURCES

Firestone

1. Passenger tire sales handbook
2. Every Women's Car Care Handbook
3. Facts on car care

1. This booklet explains the different types of tires and the explanation of serial numbers and terms makes it easy to understand when buying tires. They also explain the advantages of different types of tires.

Summary

Informative

2. The car care booklet is designed for the inexperienced driver or person who is not familiar with car servicing techniques, not necessarily women. This would be valuable for everyone.

Summary

Excellent

3. Tells each engine part and when it should be replaced, if it should be replaced and how it should perform with warnings. Very useful for most any driver who wants to know more about their car.

Summary

Very good for the novice driver or experienced

Contact

N.W. Coles
Jack B. Scarcliff
Director of Consumer Affairs
1200 Firestone Parkway
Akron, Ohi. 44317

216-379-7000

BEST COPY AVAILABLE

BEST COPY AVAILABLE

BRIEF REVIEW OF RESOURCES

Your Key To a Better Tire Buy
Uniform Tire Quality Grading
US Department of Transportation
National Highway Traffic Safety Administration

This pamphlet gives information that the more expensive tire is not necessarily the better tire. Questions and answers make this clear to anyone who reads this that they should be careful and thorough in tire selection. It tells in informative form the best tire or the good qualities in buying a tire.

Contact

US Department of Transportation
National Highway Traffic Safety Administration
Washington, DC 20590

Selection # DOTHS 804086 April 1979

BRIEF REVIEW OF RESOURCES

Consumer Information Catalog

This offers to the public free or low cost publications on a large variety of materials and information. Many different categories in nutrition, energy, dieting, housing, and economy ideas are available. Very informative.

Summary

Excellent.

Contact

Consumer Information Catalog
Consumer Information Center
Fall 1980 issue
Pueblo, [illegible]

If free, please note free on envelope

REVIEW OF RESOURCE MATERIALS IN BRIEF

27 Energy Films - Department of Energy - Oak Ridge

Included is a pink update sheet of obsolete films no longer in use. This is a catalog of films and costs on various areas in Coal, Conservation, Environment, Fusion, General, Geothermal, History, Nuclear, Solar, Space, Transportation, available to schools, colleges, libraries, and industries with ordering instructions in the rear. They especially note that they have a new phone number which is on the print out sheet.

Contact

United States Department of Energy
P.O. Box 62
Oak Ridge, Tennessee 37830

1-615-576-1285

Summary

Would be a useful tool to someone who would want to use it as a resource.

REVIEW OF RESOURCE MATERIALS IN BRIEF

Klein Film Catalog

This catalog has a variety of areas of which include the films, Working together to Save Energy, and How to Squeeze more miles from your car. They carry a free exchange service and a free lifetime repair service. The expense of the films if you have a budget run at $275.00 per. This catalog contains nearly 130 selections.

Summary

They do allow previewing of films and want your honest feedback.

Contact

David D. Jordan
Print Sales Manager
Walter J. Klein Company, Ltd.
6301 Carmel Road
Box 220766
Charlotte, NC 28222

1-704-542-1403

REVIEW OF [illegible] BOOK IN BRIEF

This book entitled Energy Future which is a report of the energy project at the Harvard Business School and edited by Robert Stobaugh and Daniel Yergin is a detailed study of a necessity with special emphasis is possible answers in our future. Other authors of articles are also credited in such topics as The End of Easy Oil, After the Peak, the Threat of Imported Oil, Natural Gas, How to Slice a Shrinking Pie, Coal: Constrained abundance, and other areas concerning nuclear, conservation, solar answers, and a conclusion. The book is located in the library and is 266 pages in length.

Summary

Book of in depth study of our fuel and energy problems with facts and predictions of our future if something isn't done.

Contact

Library - London House Inc. NY NY 10022

REVIEW OF RESOURCE MATERIALS IN BRIEF

Fuel Conservation Unit for Traffic Safety Education

from: Dr. Frank B. Brouillet - Traffic Safety Education
State Superintendent of Public Instruction
Old Capitol Building
Olympia, Washington 98504

Claire Dyckman
Project Coordinator

I enjoyed very much looking through this booklet and I wish I had one for my own. It would be a very valuable tool as long as it was updated as this one has been and I feel because of the illustrations that the student as well as the instructor would have a tough time putting it down, thus giving an interesting guide to learning and gaining facts. This is the best guide I have seen so far. The activities inside are such that it gives a student fun while learning, rather than a chore.

Contact

Claire Dyckman
Project Coordinator
Fuel Conservation Unit for Traffic Safety Education
Superintendent of Public Instruction
State of Washington
Old Capital Building FG-11
Olympia, WA 98504

Summary

A good tool and guide to use on a section on Energy Conservation with many humorous illustrations.

REVIEW OF RESOURCE MATERIALS [illegible]

Common Sense in Buying a New Car

This booklet would be very useful to the person about to buy a new car and the proper way to go about purchasing a vehicle. Headlines as: How not to buy a new car, The right way to buy your new car, Pursuing auto problems...If you have them, Where to take your complaints. These should aid anyone to make their best decision and would be to their advantage to read this guide before purchasing their next vehicle.

Summary

Very informative and should be openly available to the public before they purchase any vehicle.

Contact

Office of Public and Consumer Affairs
US Department of Transportation
Washington. DC 20590

Consumer Information Catalog

This offers to the public free or low cost publications on a large variety of materials and information. Many different categories in nutrition, energy, dieting, housing, and economy ideas are available. Very informative.

Summary

Excellent.

Contact

Consumer Information Catalog
Consumer Information Center
Fall 1980 issue
Pueblo, Colorado 81009

If free, please note free on envelope

ENERGY CONSERVATION IN PUBLIC TRANSPORTATION

IP-4. Conservation Through Car-Pooling

OBJECTIVE

Upon completion of this instructional package, you will be able to:

A. Compute the cost of operating a vehicle with one passenger as compared to operating a vehicle with five passengers.

RESOURCES

Books:

Energy Technology: Sources of Power. Schwaller, Anthony E. Worcester, Mass: Davis Publications, Inc., 1980.

U.S. Dept. of Energy Pursuant to the Provisions of the Energy Conservation and Production Acts. U.S.D.O.E. (ECPA) Pl 94-385.

Additional Resources:

Information Tables, 1P-4, 1-1 through 1-3

Materials Needed: Five (5) cars

ACTIVITY

A. Have five people living in the same area drive to school alone, then have five people ride to school together in one vehicle.

B. Compute the cost for each individual driver and sum the cost for operating five vehicles; then compare that cost with the cost of operating one vehicle which transported five people.

FEEDBACK

Objective A Check:

A. Your conclusion should have been that car-pooling save energy and that the degree of inconvenience are primary considerations when deciding whether or not car-pooling will increase.

B. Your conclusion should have been that when deciding whether or not car-pooling will increase, the two primary considerations are:

1. Car-pooling saves energy
2. The degree of inconvenience

TABLE 1

MODE(S) AND OPERATING STRATEGY	VEHICLES FOR 50 PASSENGERS	VEHICLE MILES PER DAY	FUEL
Car Pool (maximum of 5 passengers, average 3-4 passengers)	16	320	16 gallons @ 20 mpg
Van Pool (maximum of 18 passengers, average 11-15 passengers)	4	80	8 gallons @ 10 mpg
Bus			
(A) Park-ride express	1 Bus	28	6+ gallons @ 4½ mpg
with car pool feeders	16 Autos	96	5 gallons @ 20 mpg
(B) Park-ride express -	1 Bus	14	3+ gallons @ 4½ mpg
with car pool feeders - bus parking to reduce deadhead mileage	16 Autos	96	5 gallons @ 20 mpg
(C) Park-ride express - self fed	1 Bus	40	10 gallons @ 4 mpg
(D) Park-ride express - self fed Bus parking to reduce deadhead miles	1 Bus	26	6½ Gallons @ 4 mpg
(E) Local bus - self fed	1 Bus	40	13+ gallons @ 3 mpg

TABLE 2

MODE(S) AND OPERATING STRATEGY		COST NEW	ANNUAL COST
Car Pools	Autos	$112,000 (16 @ $7,000)	$22,400 (5 year life)
Van Pools	Vans	$48,000 (4 @ $12,000)	$9,600 (5 year life)
Bus			
(A) Park-ride express with car pool feeders	Bus	$150,000 (1 @ 150,000)	$10,000 (15 year life)
and			
(B) Park-ride express with car pool feeders and bus parking to reduce dead head miles	Auto	$112,000 (16 @ 7,000)	$22,400 (5 year life)
	Total	$252,000	$32,400
(C) Park-ride express - self fed,	Bus	$150,000 (1 @ 150,000)	$10,000 (15 year life)
(D) Park-ride express - self fed with bus parking to reduce dead head miles			
and			
(E) Local bus - self fed			

Information Table IP-4, 1-3

A Sample of General Relative Rankings from Another Project

Transportation System Improvement	Relative Ranking
Ridesharing	HIGH
Traffic Signalization	
Intersection	
Vehicular Flow and Roadway	MEDIUM
Parking Management and Park-and-Ride	
Peak Period Travel Reduction	
Transit (except P & R)	LOW
Paratransit (except Ridesharing)	
Bicycle	
Auto Restrictions (in central area)	

IP-5. Conserving Energy by Design

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Compare the fuel consumption of a vehicle which is designed to reduce air drag to a vehicle which is not to determine the effects of air drag.

B. Determine which engine design is most efficient.

RESOURCES

Books:

Automotive Mechanics. Crouse, W.H. New York: McGraw-Hill Book Company, 1970.

Energy Conservation: Transportation. DOE. Oak Ridge, Tennessee: U.S. Dept. of Energy, Technical Information Center, n.d.

Energy Technology: Sources of Power. Schwaller, Anthony F. Worcester, Mass: Davis Publications, Inc., 1980.

Magazines:

"What We're Already Doing to Save Energy." Changing Times, August 1977.

U.S. Department of Health, Education, and Welfare, President's Energy Message. Consumer News, May 1977, Vol. 7, (9).

NOTE: Refer to Resources in IP-3.

ACTIVITY

A. Compare the data from a trucking company to determine whether air drag consumes energy.

B. Read the literature to determine how each type of engine is designed, how it operates, and its approximate efficiency.

FEEDBACK

Objective A-B Check:

You should have concluded that air drag absorbs a significant part of the power of vehicles, particularly at higher speeds.

You should have also concluded that many improvements are being made in the design of engines for automobiles. Some improvements include the electronic ignition, precise fuel injection methods, and use of other engine designs such as diesel, gas turbine, and Stirling engines. On an average, the gasoline engine is 22% to 28% efficient; the diesel engine 32% to 38% efficient; and the gas turbine 42% to 48% efficient. The Stirling engine design is even more efficient, although certain technological improvements are still needed before it is marketable.

POST-CHECK

ENERGY CONSERVATION IN PUBLIC TRANSPORTATION

Directions: Answer the following questions by providing the appropriate response.

_____1. After starting your car in the morning, how long should you let your engine warm up before starting your trip.

_____2. How many miles can you drive at 40 mph on the gas your engine burns while idling for 10 minutes?

_____3. What percentage of gas will you save if you drive at 55 mph instead of cruising along at 70 mph?

_____4. How much money in fuel savings can the average commuter save yearly if he/she joins a car-pool?

Directions: Place the best response to each question in the space provided.

_____1. When starting from a stationary position, which car will start more efficiently?

A. A car that starts out quickly
B. A car that starts out slowly
C. More information is needed

_____2. Which of these three (3) items is most responsible for poor fuel economy?

A. Fuel Line
B. Ignition
C. Tire Pressure

_____3. If your tires are 10 lbs. below the manufacturer's recommended tire pressure maximum, how much is your gas mileage reduced?

A. 19%
B. 3%
C. 5%

MODULE NINETEEN

CONSERVING ENERGY THROUGH DRIVING HABITS

Prepared

by

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USDOE Sponsored Faculty Development Workshop on Energy
Conservation for IAE at North Carolina State University
June 1981-R.E. Wenig, Director

CONSERVING ENERGY THROUGH DRIVING HABITS

There are several proven ways in which we can conserve energy and natural resources through our driving methods.[1] Among these techniques are: knowing and driving at certain speeds, proper turning of your vehicle, correcting tire pressure, planning ahead to reduce excess trips and driving as little as possible.

After reviewing the following research, you will able to utilize the information procedures to reduce fuel energy consumption.[2] The topics covered in this module include the following: (1) How to Drive More Efficiently, (2) How to Plan Your Trips and (3) How to Care for Your Car. The activities which include testing and laboratory exercises will have to be completed by answering at least 80% of the questions on the Post-Test correctly and completing each activity under the instructor's supervision.

Achievement of the terminal performance objective will be accomplished by successfully completing three instructional packages. If you feel that you have already acquired some knowledge about conserving energy through transportation efficiency, you may wish to take the Pre-Check to determine the extent of your knowledge. The results of the Pre-Check may be used to diagnose and prescribe which or all the instructional packages needed to complete this instructional module. If you lack any knowledge about conserving via your driving methods and car care, you may eliminate the Pre-Check and begin the first instructional package. The results of your own individual diagnosis and prescription may be recorded below.

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1.	How to Drive More Efficiently	____	____
IP-2.	How to Plan Your Trips	____	____
IP-3.	How to Care for Your Car	____	____

---

[1] *It should be noted at this point that most research in this area is in pamphlet form. There is a need to compile the information found in the pamphlets into one document or text.*

A large portion of this information used to develop this module was taken from Driver/Vehicle Energy Conservation (DRIVEC) Training Program.

[2] *To obtain maximum efficiency, you must follow all of the suggestions.*

PRE-CHECK

CONSERVING ENERGY THROUGH DRIVING HABITS

Directions: Complete the blanks or place a check in the space before the best answer in the multiple choice questions.

IP-1. How to Drive More Efficiently

_____ 1. When starting from a stationary position, which car will start more efficiently?
A. a car that starts out quickly
B. a car that starts out slowly

_____ 2. How much time, over a three (3) mile city driving route, will a driver save by driving in an erratic manner with uneven speed and abrupt vehicle movement as compared to a driver who anticipates traffic and drives at a smooth and constant speed.
A. 1 minute B. 45 minutes C. almost no time at all

_____ 3. How far can you drive at 40 mph on the gas your engine burns while idling for 10 minutes? __________ miles

_____ 4. How much gas will you save if you drive at 55 mph instead of cruising at 70 mph? __________ percent

_____ 5. On the highway, at highway speed, you will generally use less gas by:
A. opening the window
B. turning on the air conditioner

_____ 6. When driving uphill, it is more efficient to:
A. start accelerating on the upgrade when your speed starts to drop
B. start accelerating just prior to starting up the hill

_____ 7. After starting your car in the morning, how long should you let your engine warm up before beginning your trip? _________

IP-2. How to Plan Your Trips

_____ 1. From a cold start, approximately how much does it cost a driver to drive four (4) miles to pick up a quart of milk? ___________

_____ 2. If one person makes a separate trip to the bus stop, the supermarket, the glass store, the drug store, and to the local school and another person goes to the same locations from next door, in three trips there will be a savings in gasoline by:
A. the person making separate trips
B. the person making 3 trips
C. no savings in gasoline

PRE-CHECK

(Continued)

3. How much money in fuel-saving can the average commuter save yearly if he/she joins a car pool? $ ________

IP-3. How to Care for Your Car

_____ 1. Which of these three items is most responsible for poor fuel economy?
A. fuel line B. ignition C. tire pressure

_____ 2. If your tires are 10 lbs. below the manufacturer's recommended tire pressure maximum, how much is that reducing your gas mileage?
A. 1% B. 3% C. 5%

3. Identify six (6) symptoms of engine operation that indicate a need to have your car checked by a mechanic.

A. ______________________________

B. ______________________________

C. ______________________________

D. ______________________________

E. ______________________________

F. ______________________________

_____ 4. If the car manufacturer specifies regular gas, will you get improved gas mileage if you use higher octane gas?
A. No B. Yes

PRE-CHECK KEY

CONSERVING ENERGY THROUGH DRIVING HABITS

IP-1. How to Drive More Efficiently

1. A
2. C
3. B
4. Over 20%
5. B
6. B
7. 30 seconds

IP-2. How to Plan Your Trips

1. $ 1.00
2. B
3. $ 300 to $ 1000 a year

IP-3. How to Care for Your Car

1. C
2. C
3. A. Hard Starting
   B. Excessive use of fuel
   C. Stalling
   D. Sputtering
   E. Black smoking
   F. Blue smoking
4. A

CONSERVING ENERGY THROUGH DRIVING HABITS

IP-1. How to Drive More Efficiently

OBJECTIVES

It is possible to conserve fuel by selecting the most appropriate driving techniques. When you finish this package, you will be able to:

A. Distinguish between the most wasteful and the most economical driving practices.

B. Describe how to drive in a manner which would conserve energy and fuel.

C. Demonstrate and explain to your colleagues how to conserve by the utilization of better driving practices.

RESOURCES

Before you begin writing objectives, you may want to review one or more of the learning resources listed below:

Pamphlets:

"55 mph - The Texas 55 mph Safer Highways Campaign"

"55 mph - Saves Lives, Gasoline and Money"

"55 Saves"

*To obtain the pamphlets above, contact:
Texas Safety Association
Texas Office of Traffic Safety
State Department of Highway and Public Transportation
Austin, Texas 78701

"Easy Ways to Cut Your Transportation Costs"

"Don't Be Fuelish"

*To obtain the pamphlets above, contact:
Dr. Frank Brouillet
Superintendent of Public Instruction
Olympia, Washington 98504

Kit:

Gas Savers, Department of Energy

ACTIVITY

We will now demonstrate how driving in a certain manner will reduce fuel consumption.

A. Start from a stationary position quickly and slowly. Record your fuel consumption when starting from both positions and compare.

B. Drive in city traffic at 8:00 a.m. in an erratic manner with uneven speed and abrupt vehicle movement. Please be careful! During the same time period, have a friend drive a vehicle of the same type (engine size, weight, etc.) through the traffic at a smooth and constant speed while anticipating traffic. Compare the amount of time utilized in both cases.

C. Let an automobile idle for ten minutes. Compute the amount of fuel consumed. Now apply the computed amount of fuel in the same automobile and determine (by driving as far as possible) the distance you can drive on the fuel consumed while idling.

D. Place an automobile on a dynamometer for 15 minutes at a speed of 55 mph. Now increase the speed to 70 mph for 15 minutes. Compare the amount of fuel used at 55 mph to the amount utilized at 70 mph.

E. Have two similar vehicles (one with windows open and the other with the windows closed and air conditioner on) drive 30 minutes at 55 mph. Compare fuel consumption.

F. Have two similar vehicles approach a hill at the same time. Let one driver accelerate on the upgrade and the other driver accelerate just prior to starting up the hill. Compare fuel consumption with accurate measuring devices.

FEEDBACK

Objective A-C Check:

The activities listed above, if conducted properly, should yield results indicative of the answers provided in the IP-1 section on the Pre-Check Key. If they did not, conduct the activities again.

Your findings in most cases should
in a certain manner will reduce fuel consumption.

____
Instructor's Approval

CONSERVING ENERGY THROUGH DRIVING HABITS

IP-2. How to Plan Your Trips

OBJECTIVES

This package will show you the importance of planning your trips which would thereby reduce their number and your fuel consumption.

A. Describe the different planning techniques

1. Car-pooling
2. Planning family errands
3. Planning social and recreational trips and, in some cases, eliminating trips

B. Establish resources to assist you in conserving fuel through planning trips.

C. Establish the techniques for comparing fuel consumption during the unplanned and planned trips on an average week.

RESOURCES

To help you reduce your fuel consumption by planning techniques, use the resources listed below.

Kit:

Gas Savers, Department of Energy

Conservation and Solar Applications

Office of Transportation Programs

Energy Efficiency
Mrs. Cynthia McLaughlin
Driver Efficiency Program
CS-830 (Resource Materials)
Department of Energy
Washington, DC 20585
Phone: 1-800-424-9043

Filmstrips:

The Driver Education Energy Conservation, by Larry L. Cathell, State of Ohio Driver Education Section, Columbus, Ohio 43215.

The Drive for Conservation

RESOURCES
(Continued)

Film:

Running on Empty

ACTIVITY

A. Record the number of trips and the amount of fuel consumed for a normal or average week. Make sure you have accurate measuring devices to determine the amount of fuel consumed.

B. Now, plan each trip and reduce the total number where possible by combining as many as possible.

C. Compare your fuel consumption for activities A & B.

FEEDBACK

Objective A-C Check:

Check your responses for objectives A, B and C with the information below.

The various planning techniques should have revealed that planning and reducing trips conserve fuel consumption.

____
Instructor's Approval

CONSERVING ENERGY THROUGH DRIVING HABITS

IP-3 How to Care for Your Car

OBJECTIVES

This package will help you (the driver) take care of your automobile and reduce fuel consumption simultaneously.

A. Properly inflate tires to highest recommended pressure to reduce friction tire wear, handling difficulty and excess stress on steering mechanisms and fuel consumption.

B. Select the best lubricants or oil for high mileage.

C. Describe the symptoms which indicate a need for certain adjustments and/or a tune-up.

RESOURCES

To help you reach your objective, you may use the resources listed below.

Pamphlet:

Best Way to Cut Your Transportation Costs!

Contact: Via Dr. Frank Brouillet - Bill Hiblar
Superintendent of Public Instruction
Olympia, Washington 98504

Get More Mileage per Gallon

Contact: Missouri **Department of Natural Resources**
Box 1309
Jefferson City, Missouri 65102

Phone: 1-800-392-0717

Booklet:

The Road to Conservation

To obtain this booklet contact:
Atlantic Richfield Company
515 South Flower Street
Los Angeles, California 90071

Champion Spark Plug Company
Box 910
Toledo, Ohio 43661

RESOURCES
(Continued)

Kit:

Gas Savers, U.S. Department of Energy

Contact: Cynthia McLaughlin
Driver Efficiency Program
CS-830 (Resource Materials)
Department of Energy
Washington, DC 20585

Books:

Automotive Mechanics by William H. Crouse, 8th ed., McGraw-Hill, New York, NY, 1980.

Auto-Mechanics by Jay Webster, Glencoe Publishing Co., Inc., Encino, CA, 1980.

Automotive Diagnosis and Tune-Up by Guy F. Wetzel, McKnight Publishing Co., Bloomington, IL, 1974.

Other:

A Mechanic or Automotive Instructor

ACTIVITY

A. Study each of the suggested resources.

B. Observe a mechanic while he completely tunes your automobile or another one.

C. Have a mechanic take you for a test drive in several faulty vehicles and attempt to diagnose the problems which may exist.

D. Decide a vehicle needs an oil change or a tune-up. Use your resources to justify your decision-making.

E. Drive a vehicle 10 psi below the maximum tire pressure for a distance of 50 miles at a speed of 55 mph, then, inflate the tires to the maximum tire pressure and again drive the vehicle the same distance and at the same speed. Compare the fuel consumption in both cases.

FEEDBACK

Objective A-C Check:

After completing the activities and reviewing the resources, you should be able to:

1. Answer the pre-test questions for this section correctly.
2. Decide when a tune-up and oil change is needed for your automobile.
3. Know how to care for your car in a manner which yields the most fuel efficient vehicle.

If you cannot perform the three itrms above, please review the resources and repeat this package.

POST-CHECK

CONSERVING ENERGY THROUGH DRIVING HABITS

DIRECTIONS: Complete the blanks or place a check in the space before the best answer in the multiple-choice questions.

1. From a cold start, approximately how much does it cost a driver to drive four (4) miles to pick up a quart of milk? ____________

2. After starting your car in the morning, how long should you let your engine warm up before starting your trip? ____________

3. When starting from a stationary position, which car will start more efficiently?
( ) A. A car that starts out quickly ( ) B. A car that starts out slowly

4. How much time, over a three (3) mile city driving route, will a driver save by driving in an erratic manner with uneven speed and abrupt vehicle movement as compared to a driver who anticipates traffic and drives at a smooth and constant speed?
( ) A. 1 min. ( ) B. 45 min. ( ) C. almost no time at all

5. How far can you drive at 40 mph on the gas your engine burns while idling for 10 minutes? ____________ miles

6. How much gas will you save if you drive at 55 mph instead of cruising along at 70 mph? ____________ percent

7. When driving up a hill, is it more efficient to: ( ) A. Start accelerating on the upgrade when your speed starts to drop ( ) B. Start accelerating just prior to starting up the hill.

8. On the highway, at highway speed, you will generally use less gas by:
( ) A. opening the window ( ) B. turning on the air conditioner

9. Which of these three (3) items is most responsible for poor fuel economy?
( ) A. fuel line ( ) B. ignition ( ) C. tire pressure

10. If your tires are 10 lbs. below the manufacturer's recommended tire pressure maximum, how much is that reducing your gas mileage?
( ) A. 1% ( ) B. 3% ( ) C. 5%

11. Identify six (6) symptoms of motor operation that indicate a need to have your car checked by a mechanic?

a. ______________________________ d. ______________________________

b. ______________________________ e. ______________________________

c. ______________________________ f. ______________________________

POST-CHECK

(Continued)

12. If the car manufacturer specifies regular gas, will you get improved gas mileage if you use higher octane gas?
( ) A. No ( ) B. Yes

13. If one person makes a separate trip to the bus stop, the supermarket, the glass store, the drug store, and to the local school and another person goes to the same locations from next door, in three trips will there be a saving in gasoline by: ( ) A. the person making separate trips ( ) B. the person making 3 trips ( ) C. no savings in gasoline

14. How much money in fuel saving can the average commuter save yearly if he/she joins a car pool? _______________

MODULE TWENTY

CONSERVING ENERGY THROUGH AUTOMOTIVE MAINTENANCE

Prepared

by

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USDOE Sponsored Faculty Development Workshop on Energy
Conservation for IAE at North Carolina State University
June 1981-R.E. Wenig, Director

CONSERVING ENERGY THROUGH AUTOMOBILE MAINTENANCE

The automobile has provided the American public with a mobility unlike any other society in the history of man. It has become an integral part of our everyday lives. The 1973 oil embargo brought first notice of the coming fuel and energy problems. In order to extend the life span of the known current supplies of fuel we must maximize the fuel economy of the 108,000,000 vehicles on the American highways.

With the knowledge of the basic auto maintenance procedures the learner can safely perform energy conservation tasks with a minimum investment in tools and equipment.

TERMINAL PERFORMANCE OBJECTIVES

Upon completion of this module you will be able to complete routine owner maintenance on a vehicle to maximize return on investment in fuel.

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1.	Fuel and Emission System Service	____	____
IP-2.	Ignition System	____	____
IP-3.	Tires and Brakes	____	____

CONSERVING ENERGY THROUGH AUTOMOBILE MAINTENANCE

PRE-CHECK

IP-1. Fuel and Emission System Service

_____ 1. Most automotive manufacturers recommend that you replace the air cleaner element:
A. Every 3000-4000 miles B. Every 6 months C. Every 6000-8000 miles D. Every 1000 miles E. Every 12 months or 12,000 miles

_____ 2. Air cleaner elements are never serviced, just replaced.
A. True
B. False

_____ 3. Two types of air filter elements are:
A. Paper and polyurethane B. Paper and wire C. Fiberglass and paper D. Fiberglass and polyurethane E. Wire and polyurethane

_____ 4. The PCV valve
A. Meters air to the carburetor B. Meters air to the valve covers C. Varies air flow in the PCV system D. Cannot reduce air pollution E. Aids in oil consumption

_____ 5. A dirty fuel filter may cause an engine to accelerate slowly.
A. True
B. False

IP-2. Ignition System

_____ 1. Most engines have the basic timing index located on the:
A. Distributor B. Flywheel C. Distributor Cap D. Carburetor E. Vibration Damper

_____ 2. The vacuum advance mechanism is usually unhooked when checking basic timing.
A. True
B. False

_____ 3. Basic timing assures correct timing at only one speed.
A. True
B. False

_____ 4. On electronic ignition systems the spark plugs require more service than any other part.
A. True
B. False

_____ 5. The spark plug heat range is determined by the:
A. Engine operating temperature B. Plug gasket C. Center electrode D. Plug shell E. Length of the insulator

PRE-CHECK

(Continued)

IP-3. Tires and Brakes

_____ 1. There are _____ basic types of tire construction.
A. 2 B. 3 C. 4 D. 5 E. 6

_____ 2. Radial tires may contribute as much as _____ percent to fuel economy.
A. 1 B. 2 C. 4 D. 5 E. 6

_____ 3. It is not advisable to mix radial tires with other types.
A. True
B. False

_____ 4. Maximum tire pressure is always stated in the owner manual.
A. True
B. False

_____ 5. Hydraulic brakes should be inspected every _____ miles.
A. 5000 B. 10000 C. 12000 D. 15000 E. 17000

PRE-CHECK KEY

CONSERVING ENERGY THROUGH AUTOMOTIVE MAINTENANCE

IP-1. Fuel and Emission System Service

1. C
2. A
3. A
4. C
5. A

IP-2. Ignition System

1. E
2. A
3. A
4. B
5. E

IP-3. Tires and Brakes

1. A
2. C
3. B
4. C

CONSERVING ENERGY THROUGH AUTOBOBILE MAINTENANCE

IP-1. Fuel and Emission System Service

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Identify and describe the operation of the air cleaner, positive crankcase ventilation valve, fuel filter and charcoal canister element filter.

B. Remove the air cleaner element, check, service and/or replace it.

C. Test the positive crankcase ventilation valve and remove and replace it.

D. Remove and replace the charcoal canister filter element.

E. Remove and replace the fuel system filters.

RESOURCES

Please review the following resources which refer to this instructional package.

Books:

Automotive Encyclopedia by Toboldt and Johnson, Goodheart Wilcox, 1968 pp.241-243.

Automotive Mechanics by Herbert Ellinger, Prentice-Hall.

ACTIVITY

A. Review the instruction materials listed in the resource section of this module.

B. Do each of the items listed below and place a check mark in front of the statement when completed.

1. Air Cleaner Service

_____ a. Open the hood on the vehicle.
_____ b. Locate the air cleaner and note attaching mechanism.
_____ c. Remove the wing nut and/or attaching bolt on the air cleaner.
_____ d. Unhook the hoses osac valve and/or temperature sensors in the air cleaner housing.
_____ e. Unhook the hot air duct to the exhaust manifold.
_____ f. Remove the air cleaner assembly to the work bench.
_____ g. Open the air cleaner assembly and remove the element.
_____ h. Observe the element and note the following conditions, check item which applies.

____________ clean and dry
____________ black and dry
____________ black and wet or oily

_____ i. Check your recommendation for this element.

____________ clean and re-use
____________ replace element

_____ j. Have your instructor check your recommendation

Instructor Signature ______________________________________

_____ k. Clean out any foreign material in the air cleaner housing.
_____ l. Re-assemble the air cleaner and element on the carburetor.
_____ m. Re-attach the vacuum lines to the air cleaner.
_____ n. Check the heat duct from the manifold to the air cleaner for alignment.
_____ o. Re-check vacuum line connection to the air cleaner and compare with vacuum hose routing chart in engine compartment.

2. Positive Crankcase Ventilation Valve Service

_____ a. Open the hood of the vehicle and locate the P.C.V. valve in the line (hose) from the carburetor base to the valve cover.
_____ b. Start the engine and let it idle.
_____ c. Pinch the hose connected to the PCV valve. If the valve is working, you will hear the engine idle speed drop.
_____ d. If the idle speed does drop the valve is working.
_____ e. If the idle speed does not drop remove any clamps on the hose and pull out the PCV valve.
_____ f. Replace the PCV valve with a new one that matches the one from your vehicle. Be sure to check application specifications.

ACTIVITY cont.

3. Charcoal Canister Filter Replacement

_____ a. Locate the charcoal canister under the hood of the vehicle.
_____ b. Note that it is attached with a circular band and one screw.
_____ c. Remove the screw (bolt) from the band, it is not necessary to remove the hoses from the unit.
_____ d. Invert the canister and note the fiberglass filter in the bottom.
_____ e. Gently pull the filter from the canister.
_____ f. Install a new filter and re-attach the canister.

4. Fuel Filter Replacement Chrysler and AMC Vehicles

_____ a. Open the hood of the vehicle and locate the fuel filter in the fuel line to the carburetor.
_____ b. Loosen the hose clamps at the ends of the filter.
_____ c. Remove the filter by pulling back on the rubber hose at each end.
_____ d. Check the hoses for signs of deterioration and replace if necessary.
_____ e. Install a new fuel filter. Note the direction of fuel flow on the filter housing. The arrow should point to the carburetor.
_____ f. Start the engine and check for leaks.

5. Ford Vehicles Fuel Filter Replacement

_____ a. Open the hood of the vehicle and remove the air cleaner. Most Ford filters screw directly into the carburetor at the fuel line inlet.
_____ b. Remove the hose clamp at the fuel line hose.
_____ c. Pull the hose free from the filter.
_____ d. Using the proper size wrench, unscrew (counter clockwise) the fuel filter and discard the unit.
_____ e. Install a new fuel filter and re-attach the fuel line hose and clamps.
_____ f. Start the engine and check for fuel leaks.
_____ g. Replace the air filter aseembly.

6. General Motors Vehicles Fuel Filter Replacement

_____ a. Open the hood of the vehicle and remove the air cleaner assembly.
_____ b. Locate the fuel line where it enters the carburetor. Most G.M. cars have the fuel filter housed in the carburetor at the fuel line inlet.
_____ c. Disconnect the fuel line at the carburetor (use two wrenches to avoid twisting the fuel line).
_____ d. With the fuel line unhooked, loosen the largest nut with a wrench. This is the fuel filter housing.
_____ e. There is a light spring behind the fuel filter. Note the positions of the spring filter and gaskets as you remove them.
_____ f. Install a new filter in the carburetor and tighten the housing.
_____ g. Re-connect the fuel line.
_____ h. Start the engine and check for leaks.
_____ i. Replace the air cleaner assembly.

FEEDBACK

Objective A-E Check:

Having completed the activities sections of this package, please report to the instructor. He will inspect your workmanship and sign your package.

Instructor's Signature

Date

CONSERVING ENERGY THROUGH AUTOMOBILE MAINTENANCE

IP-1. Ignition Systems

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Describe the importance of proper ignition timing and its relationship to good fuel economy.

B. Check and adjust basic ignition timing with a timing light.

C. Describe the operation, application and selection of spark plugs.

D. Remove, inspect, service and/or replace spark plugs.

RESOURCES

Please review the following materials which refer to this instructional package.

Books:

Same as IP-2. (Automotive Encyclopedia, 1968 Edition pp. 401-402).

Same as IP-2. (Automotive Mechanics).

ACTIVITY

A. Review the instructional materials listed in the resource section of this package.

B. Write a paper describing the three basic types of tire construction and the advantages and disadvantages of each. Draw illustration to illustrate types.

C. Upon completion of the steps noted below, place a check mark in front of the statement.

1. Checking tire inflation

_____ a. Check the owner manual for proper tire inflation pressure. Sometimes this may be found on the driver's door post. Record the proper pressure here _______ P.S.I.
_____ b. When the tires are cool, locate the valve stem.
_____ c. Unscrew the valve stem cap counter clockwise by hand.
_____ d. Apply the end of the tire pressure gauge over the tire air valve.
_____ e. Press down to obtain a pressure reading in P.S.I. on the gauge.
_____ f. Read the tire pressure indicated on the gauge.
_____ g. If the pressure is correct re-install the valve stem cap.
_____ h. If the pressure is too high depress the core in the center of the valve stem to release some air.
_____ i. Re-check tire pressure and repeat until pressure is correct.
_____ j. If the tire is under-inflated, place the end of the compressed air supply hose over the tire valve stem and depress momentarily.
_____ k. Re-check the tire pressure and repeat until pressure is correct.
_____ l. Re-install the valve stem cap.

D. Write a brief paper describing the operation of the hydraulic and parking brake system of an automobile.

E. List the major component of a hydraulic brake system.

F. Upon completion of the steps below, place a check mark in front of the statement.

_____ a. Jack the front end of a vehicle until the wheels are off the floor.
_____ b. Place jack stands under the vehicle.
_____ c. With a partner applying the brakes in the car, attempt to rotate both front wheels - they should not turn.
_____ d. With the brakes released both front wheels should turn freely. If the wheels do not turn freely, the front brakes are dragging and need to be serviced.
_____ e. Remove the jack stands and lower the vehicle.
_____ f. Repeat Steps A through D for the rear wheels.
_____ g. Apply the parking brake and repeat Steps C and D.
_____ h. Repeat Step E.

ACTIVITY

A. Review the instructional materials listed in the resource section of this package.

B. Write a one-page paper describing the relationship between ignition timing and good fuel economy.

C. Upon completion of each of the steps below place a check mark in front of the statement.

1. Engine Timing-Conventional Ignition Systems

_____ a. With the engine stopped, clean the timing marks on the harmonic balancer and engine block.
_____ b. Chalk the timing marks you want to align.
_____ c. Check the service manual for timing specification and record below ______ degrees B.T.D.C. or degrees ________ A.T.D.C. (Late model cars have the proper timing listed on the emission label under the hood.)
_____ d. Connect the timing light to the engine. The black lead wire is grounded or connected to the negative battery terminal. The red lead is positive and connected to the positive battery post. The remaining wire (larger diameter) is connected to the No. 1 spark plug with adaptors or clips over the No. 1 spark plug wire. (Check the service manual to determine #1 plug and wire)
_____ e. Make sure all wires are clear of the fan and other rotating parts.
_____ f. Start the engine and allow it to reach normal operating temperature.
_____ g. Aim the timing light at the timing marks. If the chalked marks line up, the engine is timed correctly, proceed to step K. If not lined up, proceed to the next step.
_____ h. With the engine still running loosen the distributor hold-down bolt.
_____ i. With the timing light operating, rotate the distributor housing until the timing marks line up.
_____ j. Tighten the hold-down bolt and re-check the timing.
_____ k. Stop the engine and remove timing light.
_____ l. Re-connect the vacuum line to the distributor vacuum advance.

D. Write a one-page paper describing the function and selection of spark plugs.

E. Spark Plug Service. Upon completion of each of the steps below place a check mark in front of the statement.

_____ a. With a cool engine, carefully remove the spark plug wires from the spark plugs. Numbering the wires will help you re-install them. Don't pull on the wires. Grasp the boot when removing plug wire.

_____ b. Loosen each spark plug (counter-clockwise) with a spark plug socket and ratchet. Back it out ¼ to ½ turn.

ACTIVITY cont.

_____ c. Use compressed air, if available, to blow dirt away from the plug opening.

FEEDBACK

Objective A-D Check:

Upon completion of the activities in this section, please report to your instructor. He will inspect your work.

____
Instructor's Signature

____
Date

IP-3. Tires and Brakes

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Describe the basic construction advantages and disadvantages, application and selection of automotive tires.

B. Describe the operation of the hydraulic and parking brake system in an automobile.

C. Properly check and inflate automobile tires.

D. Safely raise a vehicle and check for brake application and release at each wheel.

RESOURCES

Please review the following materials which refer to this instructional package.

Books:

Same as IP-2. (Automotive Mechanics)

Same as IP-2. (Automotive Encyclopedia, 1968 Edition pp.633-640, 511-541).

FEEDBACK

Objective A-D Check:

Now that you have completed the activities in this section, please report to your instructor. He will inspect your workmanship.

____
Instructor's Signature

____
Date

POST CHECK

ENERGY CONSERVATION THROUGH AUTOMOBILE MAINTENANCE

DIRECTIONS: Provide the appropiate response to the following questions.

IP-1. Fuel and Emission System

1. An air cleaner element that is black and oily indicates that the ______________________________ system should be serviced.

2. Clean air enter the PCV system through the ______________________________.

3. The charcoal canister filter filters air in the ________________________ ___________________system.

4. A partially plugged fuel filter will reduce the vehicle's _______________ _______________ speed operation.

IP-2. Ignition System

_____ 5. The ignition timing light is connected to the battery and:
A. the first spark plug in the firing order B. the last spark plug in the firing order C. any spark plug in the firing order D. the first and last spark plug in the firing order E. none of the above

_____ 6. Spark plugs always fire B.T.D.C.
A. True
B. False

_____ 7. A spark plug's number is determined by its heat range.
A. True
B. False

IP-3. Tires and Brakes

_____ 8. Radial tires cannot be rotated on a vehicle the same as conventional tires.
A. True
B. False

_____ 9. The parking brake system on a vehicle is operated by means of:
A. cams B. gears C. cables D. rods E. springs

_____ 10. Automotive tire pressures are more accurately checked with:
A. gas station air towers B. pencil type gauges C. visual observation

POST CHECK KEY

ENERGY CONSERVATION THROUGH AUTOMOBILE MAINTENANCE

IP-1. Fuel and Emission System

1. PCV systems should be serviced
2. Air cleaner
3. Fuel systems
4. High

IP-2. Ignition System

5. A
6. A
7. A

IP-3. Tires and Brakes

8. A
9. C
10. B

MODULE TWENTY-ONE

ENERGY EFFICIENCIES IN THE TOTAL AUTOMOBILE OPERATION

Prepared

by

Doug Adams
Industrial Arts
Chapel Hill-Carrboro
School System
Chapel Hill, North Carolina

Tom Hill
Ohio Northern University
Ada, Ohio

USDOE Sponsored Faculty Development Workshop on Energy
Conservation for IAE at North Carolina State University
June 1981-R.E. Wenig, Director

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ENERGY EFFICIENCY IN THE TOTAL AUTOMOBILE OPERATION

The module is designed to provide an individualized instruction program for analyzing energy efficiency as it relates to the total automobile operation.

TERMINAL PERFORMANCE OBJECTIVE

Each student will describe and/or demonstrate recent advances in energy efficiencies in the total automobile operation (excluding engine) as determined by a score of 90% or higher on an objective test.

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1.	Modifying Transferral of Motion		
IP-2.	Efficient Body Design		
IP-3.	Engine Modification		

PRE-TEST

ENERGY EFFICIENCIES IN THE TOTAL AUTOMOBILE OPERATION

IP-1. Modifying Transferral of Motion

_____ 1. An increase in power (beyond the highest transmission gear) obtained through advantageous gear ratios is referred to as:
A. transmission B. differential C. overdrive D. speed control E. micro-processor

_____ 2. A device that allows different gear ratios for different speeds is referred to as:
A. E(1)

_____ 3. The device that transfers motion to the rear axle is referred to as the:
A. E(1)

IP-2. Efficient Body Design

_____ 1. List three reasons how rolling resistance, wind resistance and weight can affect fuel consumption.

IP-3. Engine Modification for Automated Controls

_____ 1. The device that automatically adjusts engine functions such as fuel/air ratios is referred to as:
A. E(1)

_____ 2. The device that automatically maintains the same speed is referred to as:
A. E(1)

_____ 3. List three reasons how an MPG meter can reduce fuel consumption.

ENERGY EFFICIENCY IN THE TOTAL AUTOMOBILE OPERATION

IP-1. Modifying Transferral of Motion

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Identify advantages and disadvantages for each method of modifying transferral of motion to obtain increased efficiency as indicated by scoring 95% or higher on an objective test.

RESOURCES

Books:

Fundamentals of Automotive Transmissions by W. Thomson, 1973, Chapters 1-4, 6 and 7.

General Power Mechanics by William H. Crouse, 1976, Chapter 28.

Automechanics by Harold T. Glenn, 1976, Chapter 13.

Know Your Car by Willard A. Allen, 1974, pp. 158-163.

Information Sheet: A Consumer's Guide to Fuel Savings by National Energy Research Institute, 1979.

PRE-TEST KEY

ENERGY EFFICIENCIES IN THE TOTAL AUTOMOBILE OPERATION

IP-1. Modifying Transferral of Motion

1. C
2. A
3. B

IP-2. Efficient Body Design

Obtain answer sheet from instructor.

IP-3. Engineer Modification for Automated Controls

1. E
2. D
3. Obtain answer sheet from instructor

ACTIVITY

A. Each student will participate in the discussion of operational theory through lecture and demonstration of cut-a-way model(s).

B. Each student will draw a chart showing and listing the major components of each device.

C. Each student will define the important parts shown on the chart.

D. Each student will operate two transmissions having different gearing ratios in order to determine:
    1. obtainable RPM
    2. economy

E. Operate two differentials having different gearing ratios in order to determine:
    1. deliverable power to the wheels
    2. economy
    3. traction

F. Operate a conventional transmission and one having overdrive in order to determine:
    1. RPT (power)
    2. economy (lower engine RPM)

FEEDBACK

Objective A Check:

1. Each student will attend class.

2. Compare chart to cut-away model with parts labeled.

ENERGY EFFICIENCIES IN THE AUTOMOBILE OPERATION

IP-2. Efficient Body Design

Upon completion of this instructional package, you will be able to:

A. Name three reasons why wind resistance, rolling resistance and reduction in weight can affect operating efficiency.

RESOURCES

Books:

Running on Empty by Lester Brown, New York, Norton E. Company, 1974.

The Whole Truth About Economy by Doug Roe, 1975.

Magazines:

"Cheating the Wind," by William Gurney, III, Popular Mechanics, Nov. 1980, p. 123.

"Aerodynamics Take Off and Fuel Economy Soars," by Del Coates, Crossroads, Nov.-Dec. 1980, pp. 16, #17 and 50.

Rating Radials for Tread Life, Traction and Speed," by H. Schuldiner, Popular Science, April 1981, pp. 107-115.

"Hybrid-Tread Tire," by H. Schuldiner, Popular Science, January 1981, p. 81.

"Rubber Elephants," by William Gurney, III, Popular Mechanics, December 1980, pp. 50-53.

ACTIVITY

Participate in a lecture describing how wind resistance, rolling resistance and reduction in weight can affect operating efficiency.

FEEDBACK

Objective A Check:

Take a paper rewrite test.

IP-3. Engine Modification for Automated Controls

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Identify advantages and disadvantages for each method of modifying engines to use automated controls in order to obtain increased efficiency as indicated by scoring 95% or higher on an objective test.

RESOURCES

Books:

The Whole Truth about Economy Driving by Douglas Roe, 1975, pp. 165-169.

Automechanics by Harold T. Glenn, 1976, Chapter 6.

Magazines:

"MPG Meter" by Sid Stall, et al., Popular Science, August 1980, pp. 68-69.

"Dashboard Navigator does Everything but Drive" by William Gurney, III, Popular Mechanics, December 1980, pp. 112-13.

Informational Sheet: A Consumer Guide to Fuel Savings by National Energy Research Institute.

ACTIVITY

A. Each student will participate in a lecture describing how automated controls increase efficiency.

B. Read Popular Science article on MPG meter and draw a schematic illustrating the method of operation.

C. Arrange for students to ride in vehicle with MPG meter to see how it functions.

D. Set up a road race with three comparable cars with the **same amount of** fuel. One experimental car would have speed control and one would have a microprocessor and one conventional.

FEEDBACK

Objective A Check:

Compare schematic drawing with mark-up.

POST--CHECK

ENERGY EFFICIENCIES IN THE TOTAL AUTOMOBILE OPERATION

DIRECTIONS: Complete the puzzle per direction.

IP-1.

Write to Tom or
Dory for information

ACROSS

1. the device that allows different gear ratios for different speeds

DOWN

2. the device that transfers motion to the rear axle

4. the device that allows the engine to run slower while maintaining the same speed through an advantageous gear ratio

IP-2

6. aerodynamic drag

ACROSS

7. apposition of tire motion

8. increased economy due to a decreased load

IP-3

3. the device that automatically maintains the same speed

5. the device that automatically adjusts engine functions such as fuel/air ratio

9. a vacuum operated device that indicates fuel economy

MODULE TWENTY-TWO

CONSERVING ENERGY THROUGH AUTOMOBILE ENGINE MODIFICATIONS

Prepared

by

Tom Hill
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Doug Adams
Industrial Arts
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Chapel Hill, North Carolina

USDOE Sponsored Faculty Development Workshop on Energy
Conservation for IAE at North Carolina State University
June 1981 - R. E. Wenig, Director

CONSERVING ENERGY THROUGH AUTOMOBILE ENGINE MODIFICATIONS

Americans are finally realizing that efficiency is important. To a large degree, they are reaching this level of awareness by cost-supply factors diminishing natural resources. Many have concluded also that the "miraculous" synfuels technology presents no guarantee of meeting our energy needs. This learning sequence will directly affect your awareness of obtainable efficiency through engine modifications and, indirectly, imbue a spirit of protecting our limited resources.

NOTE: This instructional module is a beginning point in the study of engine modifications. By no means should this be considered a detailed course outline. Instead, this module represents a broad prospectus which each teacher can modify and add the detailed information necessary to accomplish energy conservation in this particular area.

TERMINAL PERFORMANCE OBJECTIVE

Each student will describe and/or demonstrate recent advances in automobile power conversion through engine modifications as determined by a score of 95% or higher on an objective.

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1.	New Propulsion Designs	____	____
IP-2.	Engine Modifications	____	____
IP-3.	Fuel Systems Modifications	____	____
IP-4.	Energy Exhibition (Optional)	____	____

PRE-CHECK

CONSERVING ENERGY THROUGH AUTOMOBILE ENGINE MODIFICATIONS

DIRECTIONS: Check your answers with the pre-check key. If you make less than 100% per section, you will need to devote time in learning about this area.

IP-1. New Propulsion Designs

_____ 1. Another name for a rotary engine is
A. Offenhauser B. Stirling cycle C. Wankel D. Carnivorous cycle

_____ 2. A car that converts both electrical and chemical energy into mechanical energy is referred to as
A. hybrid B. multiple-capacity C. Rankine-cycle D. internal combustion gasoline engine

_____ 3. An external combustion engine already proven to have a thermal efficiency of close to 40% is the
A. Stirling engine B. diesel engine C. gasoline automobile engine D. Wankel engine

IP-2. Engine Modifications

_____ 1. A device that eliminates the need to adjust the dwell (setting the points) is:
A. electronic ignition B. standard ignition C. super timing phase D. fuel injection

_____ 2. A device used to store energy in a rotating disc is the:
A. Brayton cycle B. Besler condenser C. electronic ignition D. flywheel

_____ 3. The process of using fewer pistons to provide power for the automobile is referred to as:
A. a regenerator B. turbocharging C. the V8-6-4 D. a rotary engine

IP-3. Fuel System Modifications

_____ 1. Injecting a fine spray of H_2O into the fuel stream in order to increase fuel economy is referred to as:
A. fuel injection B. electronic ignition C. water flooding D. water injection

_____ 2. The process of converting fuel into a gaseous state before it reaches the carburetor/intake manifold is referred to as:

PRE-CHECK

(Continued)

A. fuel vaporization B. fuel cell C. fuel injection D. a free-piston engine

_____ 3. The process of forcing extra fuel/air mixture into the cylinder is referred to as
A. vapor-cycle B. supercharging C. turbocharging D. transducing

_____ 4. With the use of water injection, the compression ratio of a typical gasoline automobile engine can be increased to approximately as high as
A. 8.5:1 B. 11:1 C. 13:1 D. 16:1

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CONSERVING ENERGY THROUGH AUTOMOBILE MAINTENANCE

PRE-CHECK KEY

IP-1. New Propulsion Designs

1. C
2. A
3. A

IP-2. Engine Modifications

1. A
2. D
3. C

IP-3. Fuel Systems Modifications

1. D
2. A
3. B, C
4. C

CONSERVING ENERGY THROUGH AUTOMOBILE ENGINE MODIFICATION

IP-1. New Propulsion Designs

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Describe and/or construct at least one new propulsion design which would result in greater fuel economy.

RESOURCES: Alternative Engine Designs

Books:

Alternatives to the Internal Combustion Engine by Robert U. Ayres, Baltimore: The Johns Hopkins University Press, 1972, Chap. 7-11.

Automobile Engines of Today and Tomorrow by Irwin Stambler, New York: Grosset and Dunlap, 1972, Chap. 2, 4-8.

Magazines:

"Axial-Piston Rotary Engine" by David Scott, Popular Science, August 1980, pp. 80-82, 113.

"Mazda RX-7" by Michael Lamm, Popular Mechanics, October 1980, pp. 86,87,200, 201.

"Can the Rotary Engine Survive the '80's?" by Tony Assenza, Popular Mechanics, October 1980, pp. 83-85, 206.

"Mercedes Gas Turbine" by Jan Norbye, Popular Science, March 1981, pp. 23,24.

RESOURCES: Hybrid Systems

Books:

Same as Alternative Engine Designs' Resources-IP-1. Alternatives to the Internal Combustion Engine, Chap. 12.

Same as Alternative Engine Designs' Resources-IP-1. Automobile Engines of Today and Tomorrow, pp. 108, 91, 109, 125.

RESOURCES: Hybrid Systems cont.

Magazines:

Prop-in-a-Barrel Car by Gurney Williams, III, editor, Popular Mechanics, April 1981, p. 130.

Build Your Own Hybrid: MI's Urban Town Car by Robert Riley et al., Mechanics Illustrated, February 1981, pp. 61-64.

"Can the Hybrid Car Really Help Us?" by Doug Bartholomew, Mechanics Illustrated, February 1981, pp. 65, 127.

"Running on Wind and Sun" by Gurney Williams, III, Popular Mechanics, February 1981, p. 148.

"An 84 MPG Turbo-Diesel" by Mort Schulz, Popular Mechanics, August 1979, pp. 42-44, 46, 154-158.

"An Amazing 75-MPG Hybrid Electric Car" by Robert W. Marshall, The Mother Earth News, July-August 1979, pp. 160-161.

"Mother's Own Hybrid Car," The Mother Earth News, September-October 1980, pp. 108-110.

"75 Miles Per Gallon," The Mother Earth News, March-April 1978, pp. 94-95.

RESOURCES:

Books:

Running on Empty: The Future of the Automobile in an Oil Short World by Lester R. Brown, et al., New York, NY: W.W. Norton and Company, Inc., 1979, pp. 50-63.

Magazines:

"U.S. MPG Champs" by Jim Dunne et al., Popular Science, January 1981, pp. 39-46.

"GM Designs for the '80's" by Jim Dunne, Popular Science, January 1981, pp. 86-88, 132.

"Technical Innovation: Hallmark of 1981 Autos" by Roger Rowand, Crossroads, November-December 1980, pp. 8-15, 50.

"Designed for Tomorrow" by Howard Kenig, Crossroads, May-June 1981, pp. 10-12.

"Detroit Preview: Fuel Efficient Designs for '82 and '83" by Jim Dunne, Popular Science, June 1981, pp. 84-86.

"GM Pioneers Stirling Engineering and Fine-Tunes for More MPG" by Jim Dunne, Popular Science, October 1980, pp. 118-120.

ACTIVITY

Do each one of the activities listed below:

A. Review one or more of the instructional resources listed on the preceding pages.

B. Read the directions and complete the following activities.

Each student will:

1. Participate in the discussion of operational theory through lectures and demonstrations of cut-a-way model(s).

*2. Draw one chart (chosen from a list provided by the instructor). The major components will be shown and identified on each chart.

*3. List and define the major components from the chart drawn.

*4. Modify and/or operate one new propulsion design in order to determine fuel economy as compared to a conventional engine. The instructor will provide a worksheet for the purpose of determining efficiency.

* Activities 2,3 and 4 should be carefully coordinated by the instructor. This is to assure that the students will have different activities in order to cover and then be able to share all areas.

FEEDBACK

Each student will complete the following objectives:

Objective A Check:

1. Turn in the appropriate chart and list of definitions to the instructor.

2. Turn in the worksheet to determine the efficiency of the lab experiment.

If all of the feedback objectives have been satisfactorily fulfilled (for this determination, contact the instructor), turn to the next instructional package. If you have failed to successfully complete each feedback objective, notify the instructor for further guidance.

CONSERVING ENERGY THROUGH AUTOMOBILE ENGINE MODIFICATION

IP-2. Engine Modifications

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Describe and/or construct at least one engine modification which would result in greater fuel economy.

RESOURCES: Electronic Ignition

Books:

General Power Mechanics by William H. Crouse et al., New York, NY: McGraw-Hill, 1976, pp. 184-188.

Automechanics by Harold T. Glenn, Peoria: Charles A. Bennett Company, 1976, pp. 289-292.

Running On Empty: The Future of the Automobile in an Oil Short World by Lester R. Brown, New York, NY: W.W. Norton and Company, Inc., 1979, p. 58.

Magazines:

"Understanding Electronic Ignition Systems" by Dave Bowman, Popular Electronics, July 1981, pp. 61-63.

"Servicing Your Car's Electronic Ignition" by Richard Day, Popular Science, May 1979, pp. 147-156.

RESOURCES: Flywheels: Storing Motion - Books

Alternatives to the Internal Combustion Engine by Robert U. Ayres, Baltimore: The Johns Hopkins University Press, 1972, pp. 109-113, 211, 234-237, 262-263.

Automobile Engines of Today and Tomorrow by Irwin Stambler, New York, NY: Grossett and Dunlap, 1972, p. 11.

MAGAZINES:

"Battery-Saving Flywheel" by Susan Renner-Smith, Popular Science, October 1980, pp. 82-84, 160, 161.

RESOURCES: Flywheels: Storing Motion cont.

"Engine Never Idles as Steel Flywheel Spins Out Savings"by Gurney Williams, III, editor, Popular Mechanics, June 1981, pp. 98,99.

"Search for the Perfect Flywheel" by Susan Renner-Smith, Popular Science, January 1980.

Information Sheet:

Flywheels: Storing Energy as Motion, United States Department of Energy,OPA - 001 (11-77).

RESOURCES: Reduction of Cylinders Used

Magazines:

"Cadillac's Revolutionary 3-in-1 V8"by Jim Dunne, Popular Science, October 1980, pp. 121, 122.

"Smokey Shrinks GM's V6 into a 50 + MPG 3-Cylinder Engine"by E.F. Lindsey, Popular Science, September 1980, pp. 48, 50.

"The Rise and Fall of the V8 Engine"by Rich Taylor, Popular Mechanics, December 1980, pp. 75-79, 119, 120.

"What you Should Know before Converting your V8 to a V4"by Tony Assenza et al., Popular Mechanics, December 1980, pp. 80, 81, 121.

"Convert Your V8 to a V4"by Michael Roach, The Mother Earth News, July-August 1979, pp. 144, 145.

"2-in-1 Engine"by David Scott, Popular Science, July 1979, p.60.

Information Sheet:

V8 to V4: It Is Feasible and Economical, Ohio Northern University, IP-2.

Flywheels: Storing Energy as Motion

(Department of Energy)

(Place information sheet here -
see original module)

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INFORMATION SHEET IP-2

V8 to V4:

It Is Feasible and Economical

Several years ago, I came to the conclusion that I could no longer drive my GMC truck (307 V8) because of its terrible fuel consumption. The logical choices seemed either to sell the truck or install a six-cylinder engine. A friend suggested that I convert it into a "four-cylinder." At first, I laughed. However, the more I thought, the more plausible the idea seemed. Four pistons would do the work. The other four "dead" cylinders would still reciprocate, producing no power, but maintaining the balance of the crankshaft.

To make a long story short, the following factors had to be considered:

(1) prevention of compression in the four "dead" cylinders;

(2) prevention of fuel from entering the "dead" cylinder;

(3) regulation of carburetion to the good cylinders.

These factors were achieved successfully with very little material cost.

I now have over 10,000 miles on the converted engine. The best part is this: I increased my mileage rating from approximately 11 mpg to 17 mpg overall, 20 mpg for highway driving.

NOTE: At a later date, I am going to prepare a paper detailing precisely the method of conversion used. If you would care to have a copy, notify me at 115 West Lehr Avenue, Ada, Ohio 45810. I will mail the report when it is available.

Tom Hill, Instructor
Ohio Northern University

ACTIVITY

Do each one of the activities listed below:

A. Review one or more of the instructional resources listed on the preceding pages.

B. Read the directions and complete the following activities.

Each student will:

1. Participate in the discussion of operational theory through lectures and demonstrations of cut-a-way model(s).

*2. Prepare a research paper concerning an energy conservation topic (chosen from a list provided by the instructor).

*3. Modify and/or operate one modified engine in order to determine fuel economy as compared to a conventional engine. The instructor will provide a worksheet for the purpose of determining efficiency.

*Activities 2 and 3 should be carefully coordinated by the instructor. This is to assure that the students will have different activities in order to cover and then be able to share all areas.

FEEDBACK

Each student will complete the following objectives:

Objective A Check:

1. Write a report on flywheel use in energy conservation.

2. Hand to the instructor the assigned research paper.

3. Turn in the worksheet used to determine the efficiency of the lab experiment.

4. Diagram a conventional and electronic ignition and explain the differences and similarities.

5. Write a report on cylinder size and its influence on automobile energy fuel and power consumption.

If all of the feedback objectives have been satisfactorily fulfilled (for this determination, contact the instructor), turn to the next instructional package. If you have failed to successfully complete each feedback objective, notify the instructor for further guidance.

CONSERVING ENERGY THROUGH AUTOMOBILE ENGINE MODIFICATION

IP-3. Fuel Systems Modifications

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Describe and/or construct at least one fuel system modification which would result in greater fuel economy.

RESOURCES: Water Injection

Books:

The Whole Truth about Economy Driving by Doug Roe, Tucson: H.P. Books, 1975, pp. 81-82.

Magazines:

"Water Injection: How It Works, How to Install It" by Dave Emanuel, Mechanics Illustrated, March 1981, pp. 92, 134.

"Ron Novak's Do-It-Yourself Water Injection System," The Mother Earth News, November-December 1979, pp. 114, 115.

"Water Injection Wizardry," The Mother Earth News, September-October 1979, p. 46.

"Water-Injected Turbocar," Popular Science, August 1979, pp. 122, 123.

Information Sheet:

A Consumer's Guide to Fuel Savings, National Energy Research Institute.

RESOURCES: Fuel Vaporization

Magazines:

"The Search for a No-Waste Carburetor" by Bruce Wennerstrom, Mechanics Illustrated, July 1974, pp. 47, 48.

Information Sheet:

A Consumer's Guide to Fuel Savings, National Energy Research Institute.

RESOURCES: Turbocharging/Supercharging

Books:

The Whole Truth About Economy Driving by Doug Roe, Tucson: H.P. Books, 1975, pp. 83, 84.

Supercharging of Internal Combustion Engines: Fundamentals, Calculations, Examples by K. Zinner, Chapters 1, 2, and 4.

Running on Empty: The Future of the Automobile in an Oil Short World by Lester Brown et al., New York: W.W. Norton and Company, Inc., 1979, pp. 58, 59.

Magazines:

"S-s-s-supercharger!" by Gurney Williams, III, editor, Popular Mechanics, March March 1981, p. 145.

"No-Knock Turbocar" by David Scott, Popular Science, April 1981, p. 14.

"Turbocharging Puts the Zap Back in the Z-car" by Michael Lamm, Popular Mechanics, June 1981, p. 85.

"Taking Care of a Turbocharger" by Tom Tappett, Mechanics Illustrated, January 1979, pp. 98-106.

"Water-Injected Turbocar" by David Scott, Popular Science, August 1979, pp. 122, 123.

Info 1P-2,1-1 1P-2,1-1

A CONSUMER'S GUIDE TO FUEL SAVINGS

This pamphlet is designed to provide the consumer with accurate information concerning fuel economizing techniques. Every effort has been made to make this presentation as clear and consise as possible. The pamphlet is divided into two sections. The first section lists those things which all drivers can do to cut their gasoline expenses immediately. The second section describes modifications made to a 1977 Chevrolet Impala which implemented old, well-known technologies to improve its efficiency.

SECTION 1:

The list which follows is a compilation of information from the Department of Transportation, the Department of Energy, The National Aeronautics and Space Administration, and countless academic and research institutes. The order in which items are presented is not an indication of their relative importance. Occasionally certain brand names or manufacturers are recommended. These recommendations, which are provided for the consumer's convenience, are based on data provided by the manufacturers and testing done by independent agencies.

Oils and Lubricants

(1) The next time you change your oil, change to a "low-friction" oil. We strongly recommend oils containing graphite or other "slippery" additives like those in Exxon Uniflo or the new low-friction oils from Sunoco and Gulf. These oils cost about the same as standard multigrade oils but can be expected to provide a 2 to 4% improvement in fuel economy. They also reduce engine wear. When using graphite oils, care should be taken to avoid the use of double oil filters as these sometimes tend to clog. There will be no problems however, using a standard oil filter.

(2) Change engine oil and filter frequently. Never exceed the recommended oil change intervals. This will cause unnecessary wear of the internal engine parts resulting in decreased MPG and reduced engine life. Some new oils, especially the synthetics, claim extended oil change intervals. Although the oil itself does not breakdown, there is an increase of combustion by-products which contaminate the oil and cause increased engine wear. Even these extended-life oils should be changed at frequent intervals for maximum engine protection and fuel economy. If in doubt about oil change intervals, use the following as a guide:

	City Driving	Highway Driving
New Cars	3000 miles	4000 miles
Older Cars	4-5000 miles	5-6000 miles

The investment of a small amount of money periodically will result in substantial fuel savings and longer engine life.

(3) Add a high-pressure friction modifier such as molybdenum disulfide to the lubricants in the rear axle and manual transmission (if you have one). Addition of this compound will help maintain the friction-reducing qualities of these lubricants over a large range of operating conditions.

Tires

(1) Tires are an extremely important factor in fuel economy. If you are about to buy new tires you should know that radial tires are better than bias-ply or bias-belted tires, and that low-rolling resistance radials are better than standard radials. The Goodyear *Arriva* is an exceptionally efficient, low-rolling resistance tire which can be expected to give a 4-6% fuel savings over regular radials. Since the *Arriva* costs about the same as ordinary radials, we strongly recommend it as a replacement tire.

1P-2, 1-2 1P-2, 1-2

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(2) To derive the maximum fuel-savings benefits of any tire, it is essential that they are inflated to the maximum recommended pressure (use the figure stamped on the side of the tire). This pressure should be checked when the tires are cold (i.e. before the car is driven). Since the pressure gauges on gas station air pumps are almost always inaccurate, it is important that you buy a good tire pressure gauge (cost - $2-3.00). Tire pressure should be checked weekly, especially on radial tires.

(3) Periodic tire rotation is recommended only for bias-ply or bias-belted tires. Do not rotate radial tires unless they show signs of unusual or abnormal wear. Radial tires, in their normal life, tend to wear in a certain "groove" where road contact is made. Rolling-resistance is at its minimum when radial tires operate in this fashion. Because of decreased rolling-resistance, fuel efficiency is increased and tire life extended. If radial tires are rotated, they must now wear into a new "groove". This increases rolling-resistance and decreases tire life.

(4) Balancing and wheel alignment are very important for proper vehicle handling as well as for good fuel economy and long tire life. Both of these adjustments are especially important if you have radial tires. When having tires installed, ask your mechanic to balance the tire - either static or dynamic (recommended for radials). Also have him set alignment as follows: adjust toe-in and camber to minimum setting recommended by vehicle manufacturer, and set caster to maximum positive setting specified by manufacturer.

(1) Have the engine tuned periodically. An out-of-tune engine can cause a 10-15% decrease in fuel economy. An engine should be tuned every 10,000 miles or every six months, whichever occurs first. Replace spark plugs at recommended intervals; in an 8-cylinder car, two fouled plugs can cut your fuel economy by 20%.

(2) Replace the PCV (positive crankcase ventilation) valve periodically. The PCV valve helps to maintain a balanced air/fuel mixture in the intake manifold. A clogged PCV valve will result in poor engine performance and decreased fuel economy. Also, the lack of sufficient crankcase ventilation can lead to heavy sludge formation and engine damage.

(3) The automatic choke should move freely. Inspect it periodically and adjust it to the proper position. Fuel penalties of a stuck or misadjusted choke can be as much as 3 miles per gallon.

(4) Check air filter often and replace when dirty. A clogged air filter can cut fuel economy by as much as 1 mile per gallon. Replace fuel filters as recommended by manufacturer.

Fuels

(1) Use the fuel and octane rating recommended for your car. By using gasoline with too low an octane rating you save a few cents but you increase the likelihood of knocking, especially at highway speeds or during rapid acceleration or uphill driving. Knocking is caused by the incomplete combustion of fuel in the cylinders. The unburned fuel enters the exhaust manifold and explodes there. Since fuel economy can decrease by as much as 27% during knock, you actually lose money by using a fuel with too low an octane rating. On the other hand, don't use premium fuels if your car runs fine on regular. You won't get any better gas mileage and the extra octane is wasted.

(2) Use gasohol to reduce knocking. Gasohol contains 10% ethanol (9 parts gasoline, 1 part ethanol) which helps to increase fuel octane, reducing knocking and run-on problems. If you switch to gasohol, be sure to replace your fuel filter after your first two tankfulls. The alcohol in the gasohol loosens dirt in the gas tank and fuel line and the dirt tends to accumulate in the filter. If you do not replace the fuel filter, it will become clogged resulting in poor gas mileage and possible engine damage.

Driving Habits

(1) When starting your car, do not pump the gas peddle. This dumps raw gasoline into the carburetor which can not burn completely, especially in a cold engine. If the car does not start when you follow the manufacturers recommended starting procedure, you probably need a tune-up.

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1 D-2, 1-3

(2) After the car has started don't wait longer than 30 seconds to drive. Idling gets you zero miles per gallon. Drive slowly for the first few miles until your engine and your transmission get warm. It takes about 20 minutes for your car to reach its peak efficiency. During the first few miles your car is likely to get only 30-40% of its normal fuel economy. This translates to 6-8 MPG for a car that is capable of getting 20 MPG. But even 6-8 MPG is better than the 0 MPG you get by idling.

(3) Avoid short trips (less than 10 miles) on a cold engine by combining trips when possible. Remember that your car gets its worst gas mileage during the first few miles of a trip.

(4) Accelerate smoothly and briskly. Accelerating too rapidly wastes gas by dumping too much gasoline into the carburetor. This gas does not burn efficiently. Accelerating too slowly forces the car to drive in a lower, more inefficient gear for a longer period of time. Try to get the car into high gear (more efficient) as rapidly as possible. On cars with automatic transmissions, ease up on the throttle to get the transmission to change into high gear.

(5) Try to maintain a constant speed. Accelerating costs more fuel than maintaining speed. Try to maintain your car's momentum by avoiding full stops when legally and safely possible (at yield signs for example). Starting from 2 mph is more efficient than starting from 0 mph.

(6) Drive at moderate speeds. Most cars operate at their maximum efficiency between 40 and 45 mph. Driving slower or faster than this wastes gas. When traveling on expressways or turnpikes it may be impractical or unsafe to drive this slowly so you should maintain a speed of 55 mph. You can lose as much as 20% in fuel economy by driving 70 instead of 55 mph.

(7) If you are stopped for more than one minute (for example, at a drive-in window) and your engine is warm, turn off your engine. It takes less fuel to restart your car than to leave it idling.

(8) Avoid tailgating. Try to maintain an adequate buffer between your car and the one in front of you (usually 2-3 seconds is sufficient). This will allow you enough time and space to react to changes reasonably (applying breaks gradually rather than slamming them). If someone is tailgating you, increase the buffer space in front of you even more. This will allow you enough time to react slowly so the driver behind you can stop. Don't let the tailgater intimidate you into driving inefficiently. Turn on your flashers and pull off when convenient to let him pass.

Miscellaneous

(1) Use a cruise control device for highway driving. We recommend a constant RPM type rather than a constant MPH type (See section 2 for more information).

(2) When traveling at highway speeds (above 50 mph) during the hot summer months, use your air conditioner at a moderate setting rather than rolling down windows. The air conditioner is likely to use less energy than that needed to overcome the increased drag forces caused by open windows. Besides, the air conditioner will be more comfortable

(3) Remove any extra weight you carry. Every 100 lbs extra you carry can cost you about a half mile per gallon. If your tires are in good condition and you normally drive over good roads, consider taking out your spare tire (its not really needed). The tire, wheel, jack, and lug wrench can add up to 80 lbs or more.

(4) Remove roof racks and bicycle racks when not in use. In addition to the extra weight, they increase the air resistance of the car and can significantly decrease fuel economy.

(5) Buy and use a vacuum gauge (approx. $8-16.00) to help develop fuel efficient driving habits. The vacuum gauge monitors intake manifold vacuum while you drive. The gauge has a high reading if you are obtaining good fuel efficiency and similarly a low reading for poor fuel economy. You should strive to maximize the reading under all driving conditions. With a little practice, the vacuum gauge will help you drive more efficiently.

C/b 10-2, 1-4 11-2, 1-4

(6) If you have disc brakes, you can save an additional 1-2% on your highway driving. Disc brakes, because of their design, have a tendency to drag while you are driving - they don't retract completely when the brakes are released. To get them to retract you should find a straight stretch of road (two lanes preferred). Keep your foot off the brake and switch to the left lane and then back to the right (just as if you were passing a car). Because of the "play" in your wheel bearings, the rotor will move just enough to push the disc pads back into their housing. Remember that this will work only for highway driving where you don't use your brakes often. As soon as you apply your brakes again the pads will start dragging.

(7) Keep a log of driving expenses. Include gasoline purchases and compute miles per gallon on a weekly basis. Such a record, in addition to pointing out unnecessary trips and helping you stay within your budget, will help keep you informed of any changes in your car's fuel efficiency. If you suddenly record a drop in mpg, it may be an indication that your tire pressure is low or that you need a tune up.

(8) Try ridesharing, or if your company promotes it, vanpooling to work. When two people share a ride to work they use only half the gas they would have used if they drove seperately.

(9) Take public transit when possible. In addition to the gas you'll save, you won't have to pay for a parking space when you get to your destination.

SECTION 2:

This section describes modifications made to a 1977 Chevrolet Impala. These modifications combined many of the items discussed in Section 1 (most notably the use of low-friction oil and low-rolling resistance tires) to produce a 38.3% highway mileage improvement.

The first modification involves the use of a humidification system. The addition of atomized water to the engine's inflowing air stream produces a smoother, more powerful, more complete and therefore more efficient combustion. This principle of enhancing combustion has been known for a long time - it was used on our old Corsair airplanes during World War II.

In order for the addition of water to be effective, it must be atomized (broken up into a very fine mist) before it enters the cylinders. This mist can be introduced either at the intake manifold or above the carburetor. For the FLAME auto. 10 gallons of water were stored in two 5 gallon tanks (plastic army surplus type) mounted upright, one on each side of the trunk. A hose connected them together to maintain an even level. In order to protect the engine from minerals and foreign matter which commonly occur in tap water, all water should be filtered through a good quality filter. The Barnstead model D8901 is ideally suited for this purpose and is available from Fisher Scientific Company for about $20.00. Consult your telephone directory or call or write to Fisher Scientific Company, Corporate Headquarters, 711 Forbes Avenue, Pittsburgh, PA 15219, (412) 562- 8300 for the nearest distributor.

Water is pumped forward through the filter using a 12-volt recreational vehicle pump. (In recreational vehicles, this pump is used to pump water for a small sink.) The water passes through a metering valve to an inlet cut into the carburetor's air filter cover. At this point we have gotten the water to the carburetor but it still must be broken up into a fine mist. To do this, the water is dropped onto a spinning metal disk. The disk is attached to a 12 volt hobby motor which spins at about 7000 RPM (revolutions per minute). The small motor is mounted in the air filter cover. Care was taken to keep the motor itself dry. A diagram of this system appears below.

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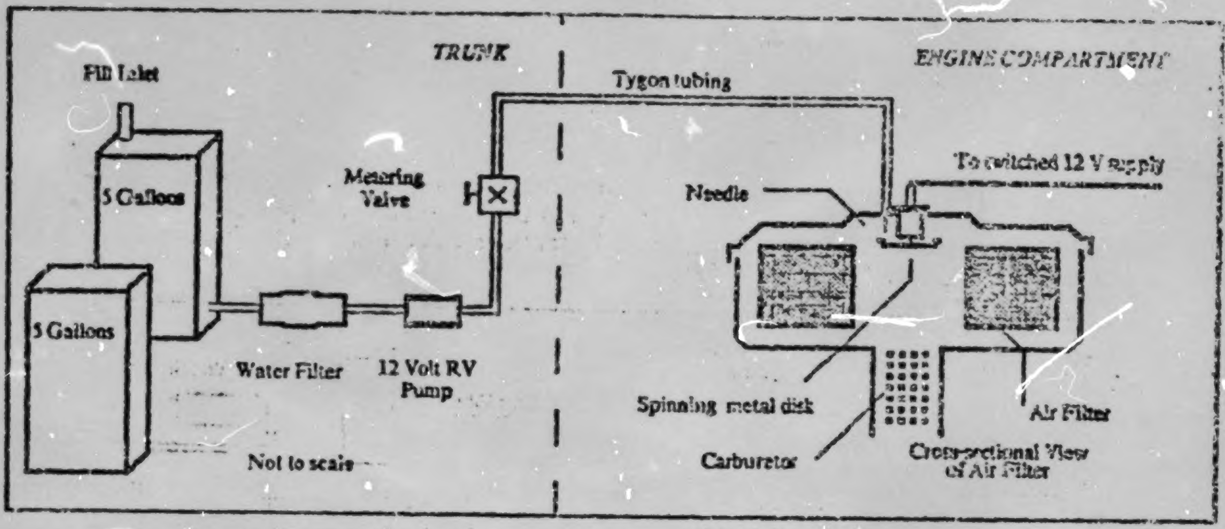

Schematic View of Humidification System

The system described above adds water mist above the carburetor. Another system, which adds humidity through the intake manifold, can be purchased as a kit for those who might prefer to install a package kit. The kit retails for about $60.00 and is called the "KenJet Fuel Economizer System", available from KenJet International, 3009 North Slappey Blvd., Albany, GA 31701, or from many NAPA auto parts distributors. Although we have provided information about a kit, we strongly encourage those with adequate mechanical ability to construct their own unit. A water addition system of this type can provide between 7 and 13% improvement in efficiency.

Another signficant fuel savings can be realized through use of a cruise control system which strives to achieve constant engine RPM. This is significantly different from the workings of most cruise controls which attempt to sense drive shaft rotation and then maintain that irrespective of the amount of gasoline they must dump into the carburetor to do this. Constant drive-shaft-rotation cruise controls can waste a lot of gas going up even a modest hill trying to maintain exact miles per hour (MPH). The engine RPM system on the other hand will allow a slight MPH increase or decrease going down or up hills. Further, this system does not require any alteration to the engine's vacuum system which is usually required to install the drive shaft monitoring system.

An engine RPM cruise control system can be purchased at most K-Mart stores and sells for about $80.00. The system K-Mart sells is called the Radatron, a division of Mark IV Industries, Niagra Falls Blvd., P. O. Box 177, North Tonawanda, New York 14120. You can write to the manufacturer directly for the address of the nearest distributor.

The last modification to be discussed is the fuel vaporization system. This along with the humidification system constitute FLAME's preconditioning system. Before we proceed with the discussion of this component we should point out that if you have implemented a good portion of the things mentioned in Section 1 and the things already mentioned above, and if you have switched to gasohol for it's anti-knock characteristics, you have probably achieved better than a 30% improvement in your highway fuel economy and you may wish to stop here with our sincere congratulations and thanks. Having gotten this far, you are to be commended for your committment to fuel conservation, a committment which will provide an immediate return in dollars saved on gasoline expenses.

With respect to FLAME's gasoline vaporization system, constuction of this unit should only be attempted by those whose mechanical abilities qualify them to make such extensive modifications. Also you should remember that gasoline is an explosive substance and the installation of a secondary carburetion system in the engine compartment may increase the chances of an engine fire, especially during a front-end collision.

The system works as follows: gasoline from the fuel tank is diverted to a vaporization chamber which has three outlets, one carrying vaporous gasoline to the intake manifold via the PCV (positive crankcase ventilation) line, one using an auxilliary electric fuel pump to carry liquid gasoline from the chamber to the regular carburetor, and the third is an overflow line which carries excess

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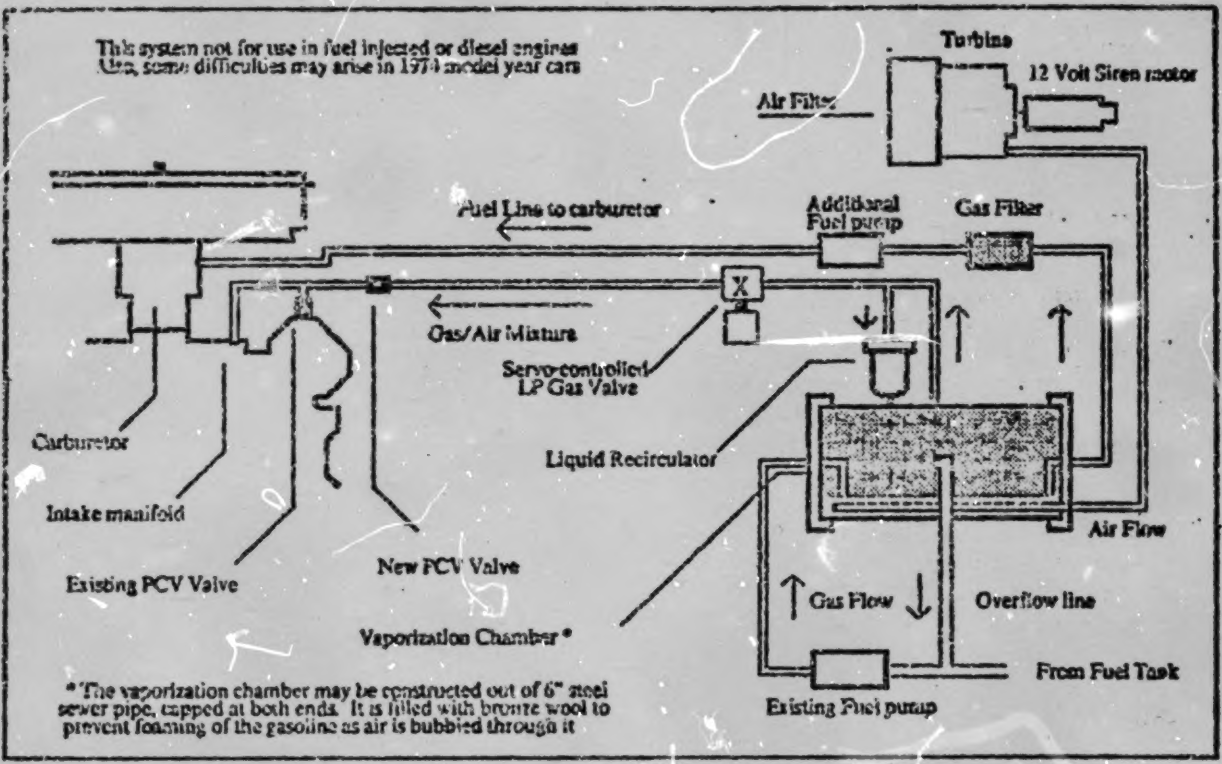
gasoline pumped to the chamber back to the fuel supply (this maintains a constant fuel level in the chamber). A filtered air supply is introduced to the chamber. In order to control the inflow of air and the outflow of vaporous fuel and air, a small turbine fan and a servo controlled natural gas valve have been used. The turbine fan is similar to that found in shop vaccum (Shop-Vac) cleaners and may be purchased as a replacement part from Sears, Roebuck and Co. A schematic diagram of the FLAME fuel vaporization system is below.


This system not for use in fuel injected or diesel engines
Also, some difficulties may arise in 1974 model year cars

Turbine
12 Volt Siren motor
Air Filter
Fuel Line to carburetor
Additional Fuel pump
Gas Filter
X
Gas/Air Mixture
Servo-controlled LP Gas Valve
Carburetor
Liquid Recirculator
Intake manifold
Air Flow
Existing PCV Valve
New PCV Valve
Gas Flow
Overflow line
Vaporization Chamber *
From Fuel Tank
Existing Fuel pump

* The vaporization chamber may be constructed out of 6" steel sewer pipe, capped at both ends. It is filled with bronze wool to prevent foaming of the gasoline as air is bubbled through it

Schematic View of Fuel Vaporization System

The. advantage of the overall system is that we get vaporous gasoline directly into the intake manifold, allowing us to "lean" the carburetor significantly. Further, the evaporation of gasoline in the chamber cools it. This in turn results in smoother combustion (an old race car driver's trick is to cool the gasoline lines with dry ice.). Extreme care must be taken to adjust the flow of vaporous fuel mixture so that it corresponds to the power output which the gas peddle indicates. This can be accomplished by adding a device which measures the position of the gas peddle (something like a potentiometer), however care must be taken no to restrict the movement of the peddle.

Some final words: The gasoline vaporization system can add between 6 and 16% to your fuel savings but on the other hand it is difficult to install and even more difficult to accurately adjust. As of this writing no kit form of this unit is available. More information about such a system can be found in Mechanics Illustrated, July 1974 issue entitled "No Waste Carburetor". Although the article makes rather extravagant claims about the virtues of vaporization, it is on the whole a good reference.

We sincerely hope that you have found this pamphlet both informative and useful. If you have already started to implement the ideas discussed here, you qualify as a WISE person (Working Industriously to Save Energy).

This information provided in the public interest by the National Energy Research Institute.

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ACTIVITY

Do each one of the activities listed below:

A. Review one or more of the instructional resources listed on the preceding pages.

B. Read the directions and complete the following activities.

Each student will:

1. Participate in the discussion of operational theory through lectures and demonstrations of cut-a-way model(s).

*2. Collect data for a particular energy conservation area (chosen from a list provided by the instructor). This information will then be compiled into a questionnaire for the public in order to increase awareness of energy facts, fallacies and possibilities.

*3. Modify and/or operate one engine with an improved fuel system. This will be compared to a conventional engine. The instructor will provide a worksheet for the purpose of determining efficiency.

*Activities 2 and 3 should be carefully coordinated by the instructor. This is to assure that the students will have different activities in order to cover and then be able to share all areas.

FEEDBACK

Each student will complete the following objectives:

Objective A Check:

1. Write a paper for review by teacher on water injection.
2. Hand to the instructor the assigned questionnaire.
3. Turn in the worksheet used to determine the efficiency of the lab experiment.

If all of the feedback objectives have been satisfactorily fulfilled (for this determination, contact the instructor), turn to the next instructional package. If you have failed to successfully complete each feedback objective, notify the instructor for further guidance.

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ENERGY CONSERVATION THROUGH AUTOMOBILE ENERGY MODIFICATION

IP-4. Energy Exhibition (Optional)

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Host an energy exhibition for the purpose of increasing public awareness which will result in greater fuel economy.

RESOURCES:

Magazines:

"The Iowa Energy 5001," The Mother Earth News, November-December 1980, p. 124.

"1403-MPG Car Wins Mileage Contest" by David Scott, Popular Science, January 1980, pp. 80-81.

DRIVEC Instructor Training, Institute for Transportation Research and Education
P.O. Box 12551, Research Triangle Park, NC 27709.

INTRODUCTION:

If used, this could be a great tool in changing attitudes toward energy. However, this would definitely require organizational ability, hard work and cooperation. Therefore, it would not be wise to attempt this unless you have assistance from your students and, hopefully, the community.

ACTIVITY

Do each one of the following activities listed below:

A. Review one or more of the instructional resources listed on the preceding pages.

B. Assemble a group of conventional and modified vehicles and/or engines in order to determine comparative fuel economy. Several schemes could be used, including:

   1) A marked course for the vehicles to travel using a measured amount of fuel.

   2) Comparative engines on test stands.

   3) Cut-a-way models of various engines.

   4) Charts, etc.

In addition, location and timing are important. Some possibilities are:

   1) State Fair

   2) Shopping Centers

   3) Trade Shows, etc.

FEEDBACK

Each student will complete the following objectives:

Objective A Check:

1. Assist the instructor in the planning of the exhibition.

2. Assist the instructor in the supervision of the actual exhibition.

If all of the feedback objectives have been satisfactorily fulfilled (for this determination, contact the instructor), turn to the next instructional package. If you have failed to successfully complete each feedback objective, notify the instructor for further guidance.

POST-CHECK

PART I.

DIRECTIONS: Draw a line around each energy related word found in the Energy Maze. The appropriate words are shown below:

- water injection
- turbocharging
- flywheel
- hybrid
- fuel vaporization
- V8-6-4
- electronic ignition
- supercharging

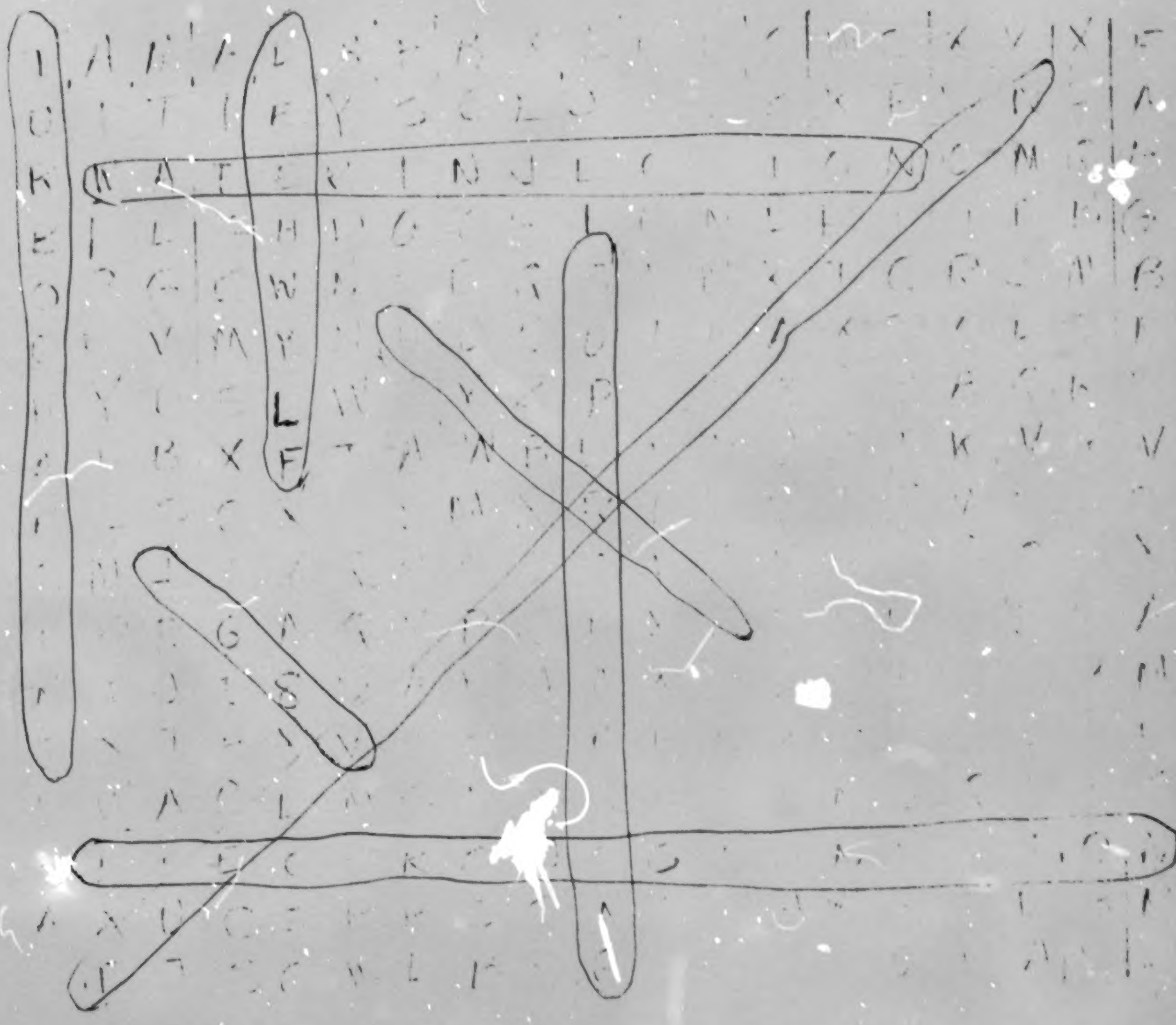
T	A	M	A	L	B	H	B	X	L	U	G	C	W	C	K	V	X	F
U	I	T	I	E	Y	S	C	E	J	J	D	Z	K	R	D	N	L	A
R	W	A	T	E	R	I	N	J	E	C	T	I	O	N	O	M	Q	H
B	F	E	G	H	D	O	O	H	F	C	N	E	P	I	I	F	B	G
O	P	G	E	W	N	L	D	Q	S	L	M	K	T	C	R	J	M	B
C	F	V	M	Y	H	H	J	U	U	I	N	A	K	T	O	L	S	N
H	Y	G	S	L	W	I	Y	Z	P	R	Z	Y	J	J	A	Q	K	F
A	H	B	X	F	T	A	W	B	E	I	H	U	Z	I	K	V	Y	V
R	L	S	C	X	L	D	M	X	R	K	X	E	T	G	W	U	U	F
G	M	A	I	Y	R	H	F	O	C	I	Q	N	H	Z	G	O	P	X
I	P	D	G	N	Q	X	P	C	H	X	D	O	R	L	I	B	N	A
N	O	J	E	8	D	A	F	M	A	X	G	L	L	H	S	I	K	M
G	X	T	H	X	V	L	U	I	R	B	N	K	G	V	J	J	C	P
P	W	A	O	L	M	G	P	X	G	Z	Q	D	N	Y	Q	F	Y	O
F	E	L	E	C	T	R	O	N	I	C	I	G	N	I	T	I	O	N
A	X	U	C	Z	R	B	S	Q	N	D	X	A	R	P	P	E	B	R
T	F	T	S	C	W	E	B	S	G	T	C	U	D	V	U	A	U	E

POST-CHECK - Key

Part 1

Directions: Draw a line around each energy related word found in the Energy Maze. The appropriate words are shown below.

water injection
turbocharging
flywheel
hybrid
fuel vaporization
V8-6-4
electronic ignition
supercharging



PART II.

DIRECTIONS: Fill in the appropriate word in each blank. Use the clues shown below.

IP-1. New Propulsion Designs

1. Across

Examples of this include the Wankel engine, gas turbine, Stirling cycle, etc.

2. Down

A combination of two or more energy sources to propel the vehicle (example: an electric/steam car).

IP-2. Engine Modifications

3. Down

A device used to increase the intensity of the spark by using a higher voltage.

4. Down

A device (non-electrical) used to store energy.

5. Across

Cadillac's version of fuel economy accomplished by decreasing the number of cylinders to power the vehicle.

IP-3. Fuel Systems Modifications

6. Across

The use of atomized water mixed with the fuel to increase fuel economy.

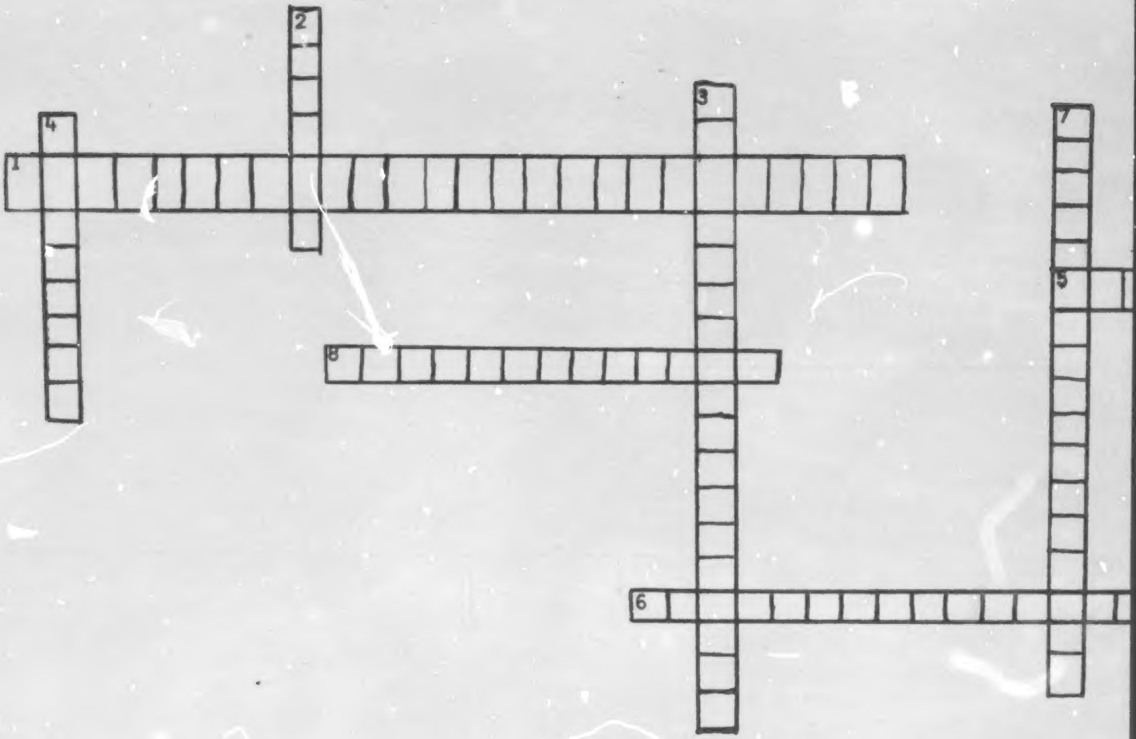
7. Down

Vaporization of fuel before it reaches the carburetor in order to increase fuel efficiency.

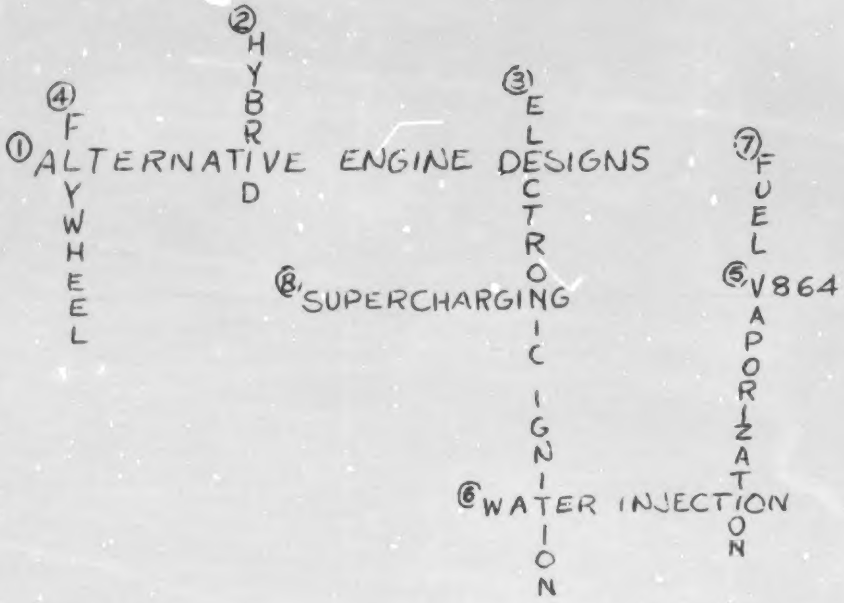
8. Across

Forcing additional fuel/air mixture into the cylinders.

Post Check Part IV



Post Check Key Part II


① ALTERNATIVE ENGINE DESIGNS
② HYBRID
③ ELECTRONIC IGNITION
④ FLYWHEEL
⑤ V864
⑥ WATER INJECTION
⑦ FUEL VAPORIZATION
⑧ SUPERCHARGING

MODULE TWENTY-THREE

HOME ENERGY MANAGEMENT SYSTEM

Prepared

by

Thomas Soyster
Temple University
Philadelphia, PA

USDOE Sponsored Faculty Development Workshop on Energy
Conservation for IAE at North Carolina State University
June 1981-R.E. Wenig, Director

HOME ENERGY MANAGEMENT SYSTEMS

One of the most critical issues facing the United States today is energy independence. Since the oil embargo of 1973 every American, regardless of age or status, continues to be acutely affected by spiraling energy costs. In view of this country's dependence on imported crude oil, for example, the public is obliged to pay the exorbitant prices imposed by foreign sources. The challenge facing this country, consequently, is twofold: (1) reduce present levels of energy consumption and (2) develop alternate domestic energy sources.

Of the many suggestions on how to reduce energy usage, one of the most immediately effective is to conserve energy through home management systems. For any conservation measure to be cost-effective, the capital outlay must be retrievable within a reasonable time. By employing analytical management procedures one is able to assess the desirability and effectiveness of any energy conserving measure. This instructional module will provide you with the information, material and practice to apply these procedures to conserve energy.

TERMINAL PERFORMANCE OBJECTIVE

At the completion of this instructional module you will be able to reduce home energy consumption, through the use of management techniques, to a specified percentage, as determined by the case under study.

Achievement of the terminal performance objective will be accomplished by successfully completing three instructional packages. Perhaps you already know something about implementing a home energy management system. If this is true you may wish to take the pre-check to determine the extent of your knowledge The results of the pre-check may be used to diagnose and prescribe the instructional packages you need to complete. If you feel that you do not have any knowledge about implementing a home energy management system, you may eliminate the pre-check and begin the first instructional package. The results of your own individual diagnosis and prescription may be recorded on the Learning Guide below:

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1.	Analyzing Energy Consumption	____	____
IP-2.	Recommending Retrofit Applications	____	____
IP-3.	Operating a Management Plan	____	____

PRE-CHECK

HOME ENERGY MANAGEMENT SYSTEMS

DIRECTIONS: Answer the following questions by placing the letter of your response in the blank space to the left of each item. Check the answers with the pre-check key, found on the page immediately following the pre-check. If you miss more than one question per section you will need to devote time in learning about this area. You may record the learning packages to study by checking the corresponding title on the Learning Guide.

IP-1. Analyzing Energy Consumption

_____ 1. Gathering information relative to the energy consumption of a dwelling is referred to as:
A. consumption survey B. energy audit C. thermal checklist D. usage chart

_____ 2. An indication of insulation value:
A. 1 B. 12 C. Cotton D. R

_____ 3. BTU's per hour ÷ 12,000 =
A. air-conditioning capacity B. thermal dissipation C. cooling velocity D. energy rate

_____ 4. An example of common insulation material:
A. Hollow Core wood B. Cellulose C. Masonry veneer D. Asbestos

_____ 5. The better insulation material:
A. Rockwool B. Glass Fiber C. Ureaformaldehyde D. Cotton Fiber

IP-2. Recommending Retrofit Applications

_____ 1. Energy conservation improvements to existing dwellings must first be proven to be:
A. inexpensive B. simple C. cost-effective D. quick

_____ 2. Structure with the highest heat transmission multiplier:
A. Masonry Wall B. Solid Wood Door C. Storm Window D. Standard-Single Window

_____ 3. Term which indicates the degree of heat transmission through the total surface of any structure:
A. Thermal Factor B. Heat Transmission Multiplier C. Coeffient of Transfer D. Diffusion Rate

PRE-CHECK

(Continued)

_____ 4. The most effective heat transmission multiplier for purposes of energy conservation:
A. .67 B. .075 C. 1.13 D. .389

_____ 5. Heat transmission is from:
A. cold to colder B. cold to hot C. hot to hotter D. hot to cold

IP-3. Operating a Management Plan

_____ 1. An energy management plan means:
A. energy audits B. retrofit applications C. budgeting and accounting energy usage D. all of the above

_____ 2. To change KWH to watts/hour:
A. multiply by 1000 B. multiply by .001 C. divide by 1000 D. divide by K

_____ 3. The abbreviation MCF is the same as:
A. 100 cubic feet B. kilowatt hours C. 1,000 cubic feet D. cubic feet per minute

_____ 4. Natural gas energy is measured in:
A. KWH B. gallons C. therms D. cubic feet

_____ 5. The most common unit for the measurement of all forms of energy:
A. KWH B. BTU C. MCF D. CCF

PRE-CHECK KEY

HOME ENERGY MANAGEMENT SYSTEMS

IP-1. Analyzing Energy Consumption

1. B
2. D
3. A
4. B
5. C

IP-2. Recommending Retrofit Applications

1. C
2. D
3. A
4. B
5. D

IP-3. Operating A Management Plan

1. D
2. A
3. C
4. D
5. B

HOME ENERGY MANAGEMENT SYSTEMS

IP-1. Analyzing Energy Consumption

OBJECTIVES

Perform an energy audit by following proper analysis procedures and completing data collection instruments to include pertinent information relative to the structural, operational and climatic control (heating and cooling) aspects of the structure under analysis.

RESOURCES

Following is a list of information resources appropriate to the content of IP-1. Analyzing Energy Consumption.

Books:

The Residential Energy Audit Manual by The Fairmont Press Inc., P.O. Box 14227, Atlanta, GA.

Home Energy Conservation Primer by Department of Technology Education, West Virginia University, Morgantown, WV.

The Complete Energy-Saving Home Improvement Guide by Arco Publishing, Inc., New York, NY.

Booklet:

The Home Energy Audit by Con Edison Conservation Center, Chrysler Building, New York, NY.

Instruction sheets IP-1, 1-5

ACTIVITY

Do each one of the activities listed below.

A. Review two or more of the previously listed instructional resources.

B. Solve each of the following problems by writing your answer in the blank space to the left.

_____ 1. To calculate the area of a rectangle multiply length times width. For example, determine the area of a room 15 ft. by 20 ft.

_____ 2. Calculate the area of a wall 20 ft.-6 in. long by 8 ft. high.

_____ 3. The "R" value of insulation is an indication of its resistance to heat flow. For example, the "R" values of some common types of insulation are listed below:

Type of Insulation	"R" Value Per Inch
Rockwool:	
Loose Fill	2.8
Blankets	3.7
Glass Fiber:	
Loose Fill	2.2
Blankets	3.1

What is the "R" value of Rockwool Blankets?

_____ 4. To determine the total "R" value of an existing level of insulation the "R" value per inch of insulation is multiplied by the insulation thickness. For example, 5" thick Glass Fiber Loose Fill would have an "R" value of ________.

C. Turn to the feedback section to check your responses.

D. Now you are ready to do an energy audit. A home energy audit is designed to help you make qualified decisions about energy conservation measures. Do an energy audit of your home by completing the following worksheet:

1 P-1, 1-1

HOMEOWNER'S WORKSHEET

Survey of Existing Conditions

1. Location: ____

Indicate the city and state in which you live. Approximate the heating and cooling load hours for your home situation.

Heating Load Hours ______________________________

Cooling Load Hours ______________________________

2. What is the primary source of heat in your home?

Oil	Heat Pump
Natural Gas	LP Gas
Electric	

3. How do you cool your home?

Window Fans or Whole-house Attic Fan
Central Air Conditioner
Window Unit Air Conditioner
None

4. What is the unit cost of the type(s) of fuel you use? (See inserted list of prices)

a. Oil $ ________/Gal

b. Natural Gas $ _______/CCF (CCF = 100 cubic feet)

c. LP Gas R ________/Gal. (LP gas includes butane or propane)

d. Electricity $ _______/KWH

5. a. What kind of exterior doors does your home now have?

Solid Wood or Hollow Core Wood
Wood Door with Storm Door

b. Determine the total area of your exterior doors. Multiply the number of exterior doors by 20 (sq. ft. door) to get the total area.

_________________(No. of Doors) x 20 = ________________ Sq. ft. of Exterior Doors

6. a. What kind of windows does your home now have?

Standard -- Single Pane
Insulated -- Double Pane
Standard with Storm Window

b. Determine the total area of your windows. Multiply the height (in feet) by the width for each of your windows and add together to find the total area.

Number X Height X Width = ________ Square feet

________ X ________ X ________ = ________

________ X ________ X ________ = ________

________ X ________ X ________ = ________

Total Window Area = ________ Sq. ft.

7. What is the size of your home?

a. Determine the total floor area of your home by multiplying its length by its width.

Length X Width = Area in Sq. Ft.

________ X ________ = ________

________ X ________ = ________

________ X ________ = ________

Total Floor Area = ________

EXAMPLE: How to Figure the Area of Your House

1. 30 X 20 = 60

2. 18 X 12 = 216

3 26 X 16 = 416

1232 Sq. ft.

b. Determine the ceiling area of your home. The ceiling area will be the same as the floor area for a one story home. In a two story house the ceiling area will equal the second story floor area plus the area of any one story sections or additions.

Total Ceiling Area = ________________

c. Determine the area of your exterior walls by multiplying the length of the wall by its ceiling height. Having determined the sub-total, subtract the total area of your doors and windows to find your total wall area.

Length	X	Height	=	Area
________	X	________	=	________
________	X	________	=	________
________	X	________	=	________

Sub-total = ________

Total Area of Doors+Windows = ________

Total Wall Area = ________

8. How is your home constructed:

a. Floors:

Concrete Slab on Grade
Wood Floors Over Vented Crawl Space or Unheated Basement

b. Ceilings:

Attic Space Above Ceiling
No Attic Space (Flat Roof or Cathedral Ceiling)

c. Exterior Walls:

Solid Masonry
Wood Frame with Wood Siding
Wood Frame with Masonry Veneer

9. Determine the existing level of insulation in your home. To determine the "R" value of your existing insulation you will have to determine what kind of insulation it is and its thickness. For attic and floors over crawl spaces, the measurement of insulation thickness is relatively simple, however, for exterior walls you may have to estimate. To determine if you have insulation in your exterior walls, turn off the power at the circuit breaker to an electrical outlet switch on an exterior wall. Remove the switch plate or outlet cover and look into the crack between the outlet box and the interior wall surface. You should be able to see if the wall is insulated. If you are unable to determine what kind of insulation you have in your attic, floors, or walls by looking at it, take a small sample of it to an insulation supplier and ask for help in identifying it.

Type of Insulation	"R" Value Per Inch
Rockwool:	
Loose Fill	2.8
Blankets	3.7
Glass Fiber:	
Loose Fill	2.2
Blankets	3.1
Cellulose:	
Loose Fill	3.7
Ureaformaldehyde	4.5
Cotton Fiber:	
Loose Fill	3.7

Having determined the type and thickness of your existing insulation, you can calculate its "R" value. From the table, determine the "R" value per inch for the type of insulation that you have in your home. Multiply that number by the thickness to get the "R" value for your existing level of insulation and record those values in the spaces provided below.

LOCATION	TYPE OF INSULATION		"R" VALUE PER INCH		THICKNESS		"R" VALUE OF EXISTING INSULATION
Attic:	________	@	________	X	________	=	________
Walls:	________	@	________	X	3.5"	=	________
Floors:	________	@	________	X	________	=	________
Example:	Rockwool Blankets	@	3.7	X	5"	=	18.5

10. Determine the output of your air-conditioning system by locating the BTU's per hour listed on the nameplate. Divide this number by 12,000 to get the number of tons. (Most residential air-conditioning systems are between 2 and 4 tons)

Tonnage of Air-Conditioner ____________________

Adapted from Home Energy Conservation: Recommendations for Existing Homes, North Carolina Department of Commerce, Raleigh, NC.

E. Check your energy audit. Have all items been completed?

F. Have one of your colleagues check your audit for errors or omissions.

G. When you feel that your energy audit is completed, submit it for your instructor's approval.

IP-1, 1-5

FEEDBACK

Check your responses for IP-1, Activity B below:

Objective A Check:

1. 300 sq. ft. (15 ft. x 20 ft.)
2. 164 sq. ft. (20 ft. x 8 ft.)
3. 3.7
4. 11 (5 x 2.2)

If you did not answer correctly one or more of the items, check with the instructor. If you answered all four correctly go to Activity D.

____

Instructor's Approval

After receiving the instructor's approval, advance to IP-[illegible]. Recommending Retrofit Applications.

HOME ENERGY MANAGEMENT SYSTEMS

IP-2. Recommending Retrofit Applications

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Recommend cost-effective retrofit applications by proposing at least one process necessary to accomplish any recommended improvement, plus calculating the savings and the amount of time required to realize a return on the initial investment.

B. Using the information that you gathered for the Homeowner's Worksheet, the second step is to determine what the thermal effects are for the energy conserving measures that you wish to consider.

RESOURCES

Following is a list of information resources appropriate to the content of IP-2. Recommending Retrofit Applications.

Books:

Al Ubell's Energy-Saving Guide for Homeowners by Warner Books, Inc., NY.

Booklets:

In the Bank . . . Or Up the Chimney by The North Carolina Agricultural Extension Service, Raleigh, NC.

Providing for Energy Efficiency in Homes and Small Buildings by U.S. Department of Energy, Oak Ridge, TN.

How to Save Money by Insulating Your Home by U.S. Department of Energy, Oak Ridge, TN

Film:

Conservation -- Investing in Tomorrow, Department of Energy Film Library, Oak Ridge, TN.

Instructional sheets IP-2,1-8

ACTIVITY

A. Review two or more of the previously listed instructional resources.

B. Solve each of the following problems by writing your answer in the blank space to the left.

1P-2,1-1

_____ 1. All surfaces in a structure transmit heat toward a cooler area. Structural materials differ in their capacity to transmit heat. Listed below are various structural surfaces and their corresponding heat transmission factor: (the higher the number, the more heat transmitted).

Structural Surface	Heat Transmission Multiplier
Windows:	
Standard-Single Glazing	1.13
Storm Window	.67
Doors:	
Solid Wood	.55
Wood with Storm Door	.34
Walls	
No insulation-Solid Masonry	.389
With R11 Insulation	.075

What is the Heat Transmission Multiplier of Storm Windows?

_____ 2. Thermal Factor is an energy conservation term which indicates the degree of heat transmission through the total surface area of any structural surface. To calculate the Thermal Factor of a structural surface multiply its surface area times its corresponding Heat Transmission Multiplier. What is the Thermal Factor of a solid wood, 3 ft. by 7 ft. -6 in. door?

_____ 3. Of the following windows, which allows the most heat transmission?

Windows	Heat Transmission Multiplier
Standard-Single Glazing	1.13
Insulating-Double Glazing	.78
Storm Window	.67

_____ 4. Of the following floors which allows the least heat transmission?

Floors: Over Crawl Space or Unheated Basement	Heat Transmission Multiplier
No Insulation	.374
with R7 Insulation	.103
with R 11 Insulation	.073
with R 13 Insulation	.064
with R 19 Insulation	.046

_____ 5. To determine a specified percentage value of any number: (a) convert the percentage value to a decimal (multiply the raw number of the percentage value by .01); and (2) multiply that decimal value times the number. For example, to determine 10% of 200:

a. 10 x .01 = .1

b. .1 X 200 = 20

Therefore, 10% of 200 = 20

What is 15% of 100?

C. Turn to the feedback section to check your responses.

D. Now you are ready to complete the second, third and fourth steps in developing a residential energy management system. Using the information that you gathered from your home energy audit, complete the following three worksheets:

The end result of the Thermal Savings Worksheet is the Thermal Savings Factor which is a measure of the reduction in consumption (in thermal terms) attributable to the energy conserving measures you wish to consider.

THERMAL SAVINGS WORKSHEET

Existing Conditions		Area In S.F.		Multiplier From Table #1		Thermal Factor
1. Existing Window Type	______,	______	X	____________	=	______
2. Existing Door Type	______,	______	X	____________	=	______
3. Existing Insulation Value in Ceiling	______,	______	X	____________	=	______
4. Existing Insulation Value in Floor (omit if Slab on Grade)	______,	______	X	____________	=	______
5. Existing Exterior Wall Type (omit if wall already has Insulation)	______,	______	X	____________	=	______

1P-2, 1-u

6. TOTAL EXISTING THERMAL FACTOR = ______ ______

Proposed Improvements

7. Proposed Window Type ______, ______ X ____________ = ____________

8. Proposed Door Type ______, ______ X ____________ = ____________

9. Proposed Insulation Value in Ceiling ______, ______ X ____________ = ____________

10. Proposed Insulation Value in Floor ______, ______ X ____________ = ____________

11. Proposed Insulation Value in Exterior Wall ______, ______ X ____________ = ____________

12. TOTAL PROPOSED THERMAL FACTOR = ____________

13. THERMAL SAVINGS FACTOR: ____________
SUBSTRACT LINE #12 FROM LINE #6
(Will be used on Line #1 of Dollar Savings Worksheet)

14. THERMAL SAVINGS RATIO ____________
DIVIDE LINE #12 BY LINE #6
(Will be used on Line #7 of Dollar Savings Worksheet)

TABLE 1

HEAT TRANSMISSION MULTIPLIER FOR DIFFERENT HOME AREAS

	Heat Transmission Multiplier
WINDOWS:	
Standard-Single Glazing	1.13
Insulating-Double Glazing	.78
Storm Window	.67
DOORS:	
Solid Wood or Hollow Core	.55
Wood with Storm Door	.34
FLOORS: OVER CRAWL SPACE OR UNHEATED BASEMENT	
No Insulation	.374
With R7 Insulation	.103
With R11 Insulation	.073
With R13 Insulation	.064
With R19 Insulation	.046
CEILINGS: NO ATTIC	
No Insulation	.470
With R4 Insulation	.160
With R5 Insulation	.130
With R7 Insulation	.109
With R11 Insulation	.076
With R19 Insulation	.047
With R26 Insulation	.035
With R30 Insulation	.031
CEILINGS: WITH ATTIC	
No Insulation	.598
With R4 Insulation	.176
With R7 Insulation	.114
With R11 Insulation	.079
With R19 Insulation	.048
With R22 Insulation	.042
With R26 Insulation	.036
With R30 Insulation	.032
WALLS:	
No Insulation -- Solid Masonry	.389
No Insulation -- Wood Siding	.320
No Insulation -- Brick Veneer	.240
With R11 Insulation	.075
With R13 Insulation	.065
With R16 Insulation	.054

The third step is to convert the reduction in consumption into a dollar savings figure. The end result will be the estimated savings on your utility bills that the energy conserving measure will produce in one year.

The accuracy of the dollar savings figure is dependent on individual energy use patterns and, for this reason, cannot be guaranteed. However, under normal conditions these calculations should provide you with a reasonably accurate means of assessing energy savings. Complete the following Dollar Savings Worksheet.

DOLLAR SAVINGS WORKSHEET

1. THERMAL SAVINGS FACTOR ______________________
   From Thermal Savings Worksheet (#13)

2. HEATING DEGREE HOURS ______________________
   From Homeowner's Worksheet (#1)

3. UNIT PRICE OF FUEL USED FOR HEATING ______________________
   From Homeowner Worksheet (#4)

4. MULTIPLY LINE #1 X LINE #2 X LINE #3 ______________________

5. ADJUSTED HEATING EFFICIENCY FACTOR ______________________
   Select the adjusted efficiency factor for the type of furnace that you have.

#2 Fuel Oil	59,000
Natural Gas	60,000
Electric Furnace	3,070
LP Gas	55,200
Heat Pump	6,826

____

6. DOLLAR SAVINGS FOR HEATING ______________________
   Divide Line #4 by Line #5

7. THERMAL SAVINGS RATIO ______________________
   From Thermal Savings Worksheet (#14)

8. FULL LOAD COOLING HOURS ______________________
   From Homeowner's Worksheet (#1)

9. TONNAGE OF AIR CONDITIONING UNIT ______________________
   From Homeowner's Worksheet (#10)

10. MULTIPLY LINES #7 X #8 X #9 ______________________

11. MULTIPLY LINE #10 X 1.78 for WINDOW UNIT
    or 1.63 for CENTRAL UNIT ______________________

12. UNIT PRICE OF ELECTRICITY IN $/KWH ______________________
    From Homeowner's Worksheet (#4)

13. DOLLAR SAVINGS FOR COOLING
MULTIPLY LINE # 11 x LINE # 12

14. TOTAL DOLLAR SAVINGS
ADD lINES # 6 + #13

The fourth step is to determine the payback period. The payback period is the number of years that it will take an energy conserving measure to "pay itself." After an energy conserving measure has been in effect for its payback period, it will generate "profits" in the form of savings on your utility bills. Complete the following Payback Period Worksheet.

PAYBACK PERIOD WORKSHEET

1. COST OF ENERGY CONSERSERVING MEASURE
Contractor's Bid or Estimate of Do-It-Yourself Costs

2. FEDERAL TAX CREDIT
(15% up to $300)

3. SUBTRACT LINE 2 FROM LINE 1

4. TOTAL DOLLAR SAVINGS
From Dollar Savings Worksheet (#14)

5. PAYBACK FACTOR
Divide Line #3 by Line #4

6. ADJUSTED PAYBACK PERIOD
From Table No. 2

E. Check your worksheets. Have all items been completed?

F. Have one of your colleagues check your worksheets for errors or omissions.

G. When you feel that your worksheets are completed, submit them for your instructor's approval.

(P–E) ·

TABLE NO. 2

PAYBACK CHART AT 10% FUEL COST INCREASE

Using the Payback Chart

Costs for all types of fuels are expected to increase over the coming years. In figuring your adjusted payback period, we will use a standard increase in utility costs of 10% per year. The Payback Period Chart takes this into consideration as well as the effects of borrowing money to implement the energy conserving measure. If you are borrowing money to install an energy conserving measure, select the column that comes closest to the interest rate at which you will be borrowing the money. By reading down the appropriate column until you come to the number closest to the "Payback Factor" and then across to the Payback period scale, you will be able to determine how long it will take for an energy conservation measure to pay for itself.

NOTE: If you are not going to borrow money to pay for the energy conserving measure but are going to withdraw money from a savings account, use the column that comes closest to the interest rate that your money would have earned had it remained in your savings.

Payback [illegible]od in Years

	Interest Rates							
YEAR	**6.0**	**7.0**	**8.0**	**8.5**	**9.0**	**9.5**	**10.0**	**18.0**
2	1.92506	1.89842	1.87241	1.85967	1.84707	1.83462	1.82281	1.6492
3	2.494922	2.8955	2.8434	2.81794	2.79286	2.76816	2.74383	2.39895
4	4.02039	3.93001	3.8429	3.80051	3.75888	3.718	3.67784	3.12114
5	5.14388	5.00642	4.87518	4.8116	4.74934	4.68836	4.62863	3.81834
6	6.32336	6.12946	5.94472	5.85562	5.7686	5.68836	5.60058	4.49769
7	7.56586	7.30416	7.05625	6.93717	6.82121	6.70826	6.59822	5.1658
8	8.87681	8.53589	8.21474	8.06113	7.91195	7.76702	7.6262	5.82882
9	10.2626	9.83038	9.4255	9.23263	9.04581	8.86481	8.68939	6.49253
10	11.7301	11.1938	10.6941	10.4571	10.2281	10.0068	9.79286	7.16242
11	13.2866	12.6327	12.0267	11.7403	11.4644	11.1984	10.9419	7.84375
12	14.9402	14.1541	13.4295	13.0884	12.7606	12.4454	12.1422	8.54164
13	16.6994	15.7656	14.9094	14.5079	14.123	13.7538	13.3995	9.26112
14	18.5734	17.4753	16.4737	16.0059	15.5584	15.1302	14.7202	10.0072
15	20.5722	19.2921	18.1304	17.5897	17.0739	16.5814	16.1109	10.7848
16	22.7065	21.2253	19.8878	19.2676	18.6771	18.1148	17.5788	11.5991
17	24.9881	23.2851	21.7549	21.0479	20.3764	19.7382	19.1313	12.4552
18	27.4294	25.4826	23.7417	22.9401	22.1805	21.4602	20.7765	13.3584
19	30. 0442	27.8295	25.8585	24.9541	24.0989	23.2897	22.5232	14.3144
20	32.847	30.3386	28.1167	27.1006	26.1419	25.2365	24.3807	15.3289

The three previous worksheets and two tables were adopted from Home Energy Conservation: Recommendations for Existing Homes, North Carolina Department of Commerce, Raleigh, North Carolina.

FEEDBACK

Objective A Check:

1. .67
2. 12.38 (3x7.5 = 20 x .55 = 12.38)
3. Standard - Single Glazing
4. R19 Insulation
5. 15 (15 x .01 = .15 x 100 = 15)

If you did not answer correctly one or more of the items, check with the instructor. If you answered all five correctly, go to Activity D.

____
Instructor's Approval

After receiving the instructor's approval, advance to IP-3. Developing A Management Plan.

IP-3. Developing a Management Plan

OBJECTIVE

Upon completion of this instructional package, you will be able to:

A. Initiate and operate a plan to manage the consumption of energy by budgeting and accounting for energy usage.

Being aware of the possibilities for saving money and energy is only the beginning step toward an energy management system. The previous worksheets have presented some ideas for saving energy in your home. Now it is up to you to get the wheels in motion and implement the applicable conservation measures. An organized system of priorities should be established to decided where to focus your efforts. The worksheets enclosed in this section are designed to help you organize your list of priorities.

RESOURCES

Following is a list of information resources appropriate to the content of IP-3. Developing a Management Plan.

Book:

Homeowner's Guide to Saving Energy. Tab Books Inc., Blue Ridge Summit, PA, pp. 361-377.

Booklets:

Energy Efficiency for Educators and Students. Tenneco, Inc., Houston, Tx.

Load Management: Reshaping America's Electric Demand. Duke Power Co., Charlotte, North Carolina.

Film:

An Introduction to Energy Management, DOE Film Library, Technical Information Center, Oak Ridge, TN.

ACTIVITY

A. Review at least two or more of the previously listed instructional resources.

B. Solve each of the following problems by writing your answers in the blank spaces. This problem is an example of how to determine the energy savings of a typical energy conservation measure:

In this situation, 150 watt bulbs are being replaced by 75 watt blubs and operated 6 hours per night.

Data needed for calculations:

1. 20 lights at 150 watts

2. The total energy used is:

   20 lights x 150 watts/light = 3000 watts/day

3. Average number of hours per day the lights are currently on:

   6 hours/day

4. Number of days per year the lights are on:

   365 days/year

5. Number of watts per new bulb:

   75 watts

6. Average number of hours per day the new lights will be on:

   6 hours

7. Electricity cost per KWH average (from your local electric utiiity company).

   $0.06/KWH

Calculations:

1. Energy used with old system:

_____ no. bulbs x

_____ watts/bulb

x _____ no. operating hours/day

x _____ no. days/year ÷ 1000

= _____ KWH/year

2. Energy used with new system:

_____ no. watts/bulb x _____ no. bulbs

x _____ no. operating hours/day

x _____ no. days/year ÷ 1000

= _____ KWH/year

3. KWH saved per year:

_____ KWH/year (old system)

_____ KWH/year (new system)

= _____ KWH saved/year

4. Energy cost savings:

_____ KWH saved/year x

_____ $/KWH

= _____ $/year

(This assumes that the old bulbs would have no value and would be thrown away. If a value could be assigned to them, this value would be subtracted from the cost in the above equation.)

5. Payback period:

bulb cost (@ $1.20/bulb)

____

energy savings first year

_____ years = payback period

C. Turn to the feedback section to check your responses.

D. Now you are ready to complete the fifth and final step **in developing a** residential energy management system. Complete the following two worksheets.

Use the first worksheet to record data concerning the no-cost or low-cost improvements which you intend to implement.

ACTION PLAN

IMPROVEMENTS	COST	PAYBACK PERIOD	COMPLETION DATE	REMARKS

Adapted from Saving Money with Energy Conservation: An Energy Audit Workbook for Public Assembly, DOE, Washington, DC

In order to determine just how much was saved and for future savings and cost estimates, an Energy Management Form is also included in this section. The Energy Management Form is to be used to monitor your energy consumption and costs. By doing this, you can trace the results of your program and keep up on your real energy costs.

An Energy Management Form is shown on the following page. The data from the form can be used to budget and account for energy usage. In addition, it can be used to calculate the payback period for several of the recommended energy conservation measures illustrated.

To make it easy to use, you may wish to remove it from the book. The form is intended to be an aid for establishing a continuing energy bookkeeping procedure for your building. If it is filled out each month, the [redacted] owner of the building can get a sense of monthly and yearly energy consumption and cost. It can be used as a base to evaluate energy savings that result from energy conservation measures.

You should remember that the billing period for electricity may vary from 25 to 40 days. If so, you will have to adjust it to be consistent with other types of energy on the form. Calculate the kwh per day and multiply by the number of days in the month or period you are using for oil and gas.

Continue to update the Energy Management Form at regular, frequent intervals during the implementation of your energy conservation program. That way, the reduced consumption of fuel and/or electricity will become real and you will be able to demonstrate and verify the savings with your consumption measurements.

The following abbreviations are used in the Energy Management Form:

MCF = 1,000 Cubic Feet
CCF = 100 Cubic Feet
KWH = Kilowatt Hours
CFM = Cubic Feet per Minute

[illegible] YOUR ENERGY USAGE FROM $'S to BTU'S

The British Thermal Unit or Btu is a common unit for the measurement of all forms of energy. With the increase in unit cost for utilities it will be difficult to measure energy usage and savings on the basis of dollar amount of the utility bills. Conversion to Btu's eliminates the differences in units used to measure various types of fuel, as well as variations in price for fuels in different geographic regions and future price increases. A Btu is a very small unit of energy. Large quantities of energy are often expressed in terms of a million Btu's or in some cases therms*. Converting dollar energy usage to Btu's is a simple process, and will allow additional analysis of the figures in the Energy Management Form.

Source	*Measure*	*Energy*
electricity	kwh	3412 Btu's
natural gas	cubic foot	1030 Btu's
*natural gas	1 MCF	10 Therms
oil	gallon	140,000 Btu's
steam	1 lb.	1390 Btu's

BUILDING ____________________ ____________________ YEAR

MONTH*	ELECTRICITY			OIL			NATURAL GAS			COAL ☐ WOOD ☐ PURCHASED STEAM ☐ other ________			TOTAL ENERGY COST
	QUANTITY KWH	COST (DOLLARS)		QUANTITY GALLONS	COST (DOLLARS)		QUANTITY MCF. CCF. OR THERMS	COST (DOLLARS)		QUANTITY UNIT	COST (DOLLARS)		
		TOTAL $	$/KWH		$/GAL	TOTAL $		TOTAL $	$/MCF		TOTAL $	$/UNIT	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
JANUARY													
FEBRUARY													
MARCH													
APRIL													
MAY													
JUNE													
JULY													
AUGUST													
SEPTEMBER													
OCTOBER													
NOVEMBER													
DECEMBER													
ANNUAL TOTALS													
ANNUAL AVERAGES													

Adapated from Saving Money with Energy Conservation: An Energy Audit Workbook for Public Assembly, DOE, Washington, DC 627

*Or comparable time period

E. Check your worksheets. Have all items been completed?

F. Have one of your colleagues check your worksheets for errors or omissions.

G. When you feel that your worksheets are completed, submit them for your instructor's approval.

FEEDBACK

Objective A Check:

1. 20 bulbs x 150 watts/bulb
   x 6 hours/day
   x 365 days/year ÷ 1000
   = 6570 KWH/year

2. 75 watts/bulb x 20 bulbs
   x 6 hours/day
   x 365 days/year
   = 3285 KWH/year

3. 6570 KWH/year (old system)
   - 3285 KWH/year (new system)
   = 3285 KWH saved/year

4. 3285 KWH saved/year x $0.06/KWH
   = $197.10/year

5. $\frac{\$24.00}{\$197.10}$

   = .12 years or 1.5 months

If you did not answer correctly one or more of the items, check with the instructor. If you answered all five correctly, go to Activity D.

Instructor's Approval

After receiving the instructor's approval, advance to the Post-Check.

POST-CHECK

HOME ENERGY MANAGEMENT SYSTEMS

Directions: Given all the necessary data from a hypothetical residence and the required worksheets, perform each of the following tasks:

1. Conduct an energy audit to include the structural, operational, and climatic control (heating and cooling) aspects of the structure.
2. Complete a Thermal Savings Worksheet, Dollar Savings Worksheet, and Payback Worksheet. From the information generated by these worksheets, recommend conservation measures that would reduce overall energy consumption by at least 10%. Show your calculations for the savings and the amount of payback time.
3. Initiate and operate an energy managment plan for three months by completing an Action Plan Worksheet along with the proposed improvement Energy Management Form to budget and account for energy usage.

MODULE TWENTY-FOUR

PRINCIPLES AND PRACTICES OF RE-USING ENERGY SUPPLIES

Prepared

by

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USDOE Sponsored Faculty Development Workshop on Energy
Conservation for IAE at North Carolina State University
June 1981-R.E. Wenig, Director

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PRINCIPLES AND PRACTICES OF RE-USING ENERGY SUPPLIES

In order for us to live with the limited resources of the world and to reserve those resources for the future, we must learn to recycle more waste. The recycling business has become more attractive each day. At last, environmentalists and economists are beginning to work together in helping us to realize the importance of producing energy from waste to renew dwindling resources.

TERMINAL PERFORMANCE OBJECTIVE

Upon completion of this module, you will complete a performance test (quiz) with 80% efficiency related to the basic principles and practices of recycling critical materials that would have been considered waste.

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1.	Identification of Materials	____	____
IP-2.	Local Laws on Waste Disposal Must Be Observed	____	____
IP-3.	Conventional and Unconventional Methods of Handling Waste	____	____
IP-4.	The Recovered Product	____	____

PRE-CHECK

DIRECTIONS: Check the answers with the pre-check key. If you miss one true or false question per section, you will need to devote time in learning about this area.

IP-1. Identification of Materials

TRUE FALSE

1. _____ _____ The word wastes refers to materials discarded by community activities, and includes solids, liquids and gases.

2. _____ _____ Garbage is domestic or household food waste. Rubbish is domestic non-food waste, and residential waste or domestic waste is the combination of garbage and rubbish.

3. _____ _____ The term "recycling" in its narrowest, and probably original, sense does not denote the return of a discarded material or article to the same product system.

4. _____ _____ Solid wastes municipal refuse, industrial trash and demolition debris have a very low recovery rate.

IP-2. Local Laws on Waste Disposal Must Be Observed

1. _____ _____ Recycling is the process by which recovered resources are transformed into new products in such a manner that the original products lose their identity.

2. _____ _____ Solid waste management is a purposeful, systematic control of the generation, storage, collection, transport, separation, processing, recycling, recovery and disposal of solid waste.

3. _____ _____ Senate Joint Resolution 1073 ratified April 12, 1974 appointed a four-person commission to investigate and monitor all recycling requests for the state.

4. _____ _____ North Carolina has always had a comprehensive listing of persons and organizations involved in the recycling process.

IP-3. Conventional and Unconventional Methods of Handling Wastes

1. _____ _____ In the United States the early industrial-waste plans were those for treatment of tannery and glue-factory wastes in Massachusetts, and they operated on the unconventional method.

2. _____ _____ One of the early American industrial-waste-treatment plants mechanically cleaned tanks, thereby eliminating the objectionable job of removing the sludge by manual means.

PRE-CHECK

(Continued)

3. _____ _____ The "step-sludge" method is considered conventional.

4. _____ _____ The unconventional methods have all been developed to reduce size and cost of waste treatment plants.

IP-4. The Recovered Product

1. _____ _____ A beer company (Coors) uses a Carver-Greenfield drying process to recover high amounts of crude protein and vitamin B-12 for subsequent use in baby formulas.

2. _____ _____ The research center of the Bureau of Mines has used fly ash, a by-product of electric generating plants, as a partial substitute for cement in a sidewalk in Morgantown, West Virginia.

3. _____ _____ Flea markets, garage sales are methods of recycling residential waste.

4. _____ _____ Louisiana State University operated a pilot plant which fermented sugar cane bagasse into edible, single-cell protein competitive with soybean flour or cornmeal.

PRE-CHECK

IP-1. Identification of Materials

1. T
2. T
3. F
4. F

IP-2. Local Laws on Waste Disposal Must Be Observed

1. T
2. T
3. F
4. F

IP-3. Conventional and Unconventional Methods of Handling Wastes

1. F
2. T
3. F
4. T

IP-4. The Recovered Product

1. F
2. T
3. T
4. T

PRINCIPLES AND PRACTICES OF RE-USING ENERGY SUPPLIES

IP-1. Identification of Materials

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Identify major materials that are considered waste.

B. Categorize waste materials according to liquids and solids.

RESOURCES

Books:

Resource Recovery and Recycling by Allan F.M. Barton, Chapter 1, pp. 1-12.

ACTIVITY

A. Please read the resource listed in the resource section.

B. The student will list 20 materials that are considered waste products in his/her project.

C. Please list all waste materials into two divisions; liquids and solids.

D. The student will explain in chart form the properties of the original product before being recycled, also consider if the product in its present state is worth the cost, time and energy to be recycled.

FEEDBACK

Objective A and B Check:

Refer back to Pre-Check for IP-1 questions and answers.

If you did not answer correctly all questions, check with your instructor.

If you answered all four correctly, go to IP _____ (Objective) _____ .

____
Instructor's Approval

PRINCIPLES AND PRACTICES OF RE-USING ENERGY SUPPLIES

IP-2. Identification of Materials

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. State laws on waste disposal must be observed.

B. List the requirements on how to store waste by reviewing laws where he/she is located.

RESOURCES

Books:

Report of the Commission for the Study of Solid Waste Recycling to the 1975 General Assembly of North Carolina, February 28, 1955.

ACTIVITY

A. Please read the complete resource listed in the resource section.

B. Student should list the laws of the State in which he/she lives and describe how to handle waste for recycling.

C. A list should be made of those laws that act as a hindrance/assistance to cost and time in recycling liquids and solids.

FEEDBACK

Objective A and B Check:

Refer back to Pre-Check for questions and answers.

If you did not answer correctly all questions, check with your instructor.

If you answered all four correctly, go to IP- ____ (Objective) _____ .

____
Instructor's Approval

PRINCIPLES AND PRACTICES OF RE-USING ENERGY SUPPLIES

IP-3. Conventional and Unconventional Methods of Handling Waste

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Study at least one conventional and one unconventional method of treating industrial/residential wastes.

RESOURCES

Books:

The Treatment of Industrial Wastes by Edmund B. Besselievre, Chapter VIII.

Recycling by Jerome Goldstein, Chapters III and VIII.

ACTIVITY

A. Please read the resources listed in the resource section.

B. Students should list each method of waste disposal explaining their origin, advantages, disadvantages and the type wastes involved.

C. Students should compare recovered waste cost, time and energy, and the method of recycling to the original state.

FEEDBACK

Objective A Check:

Refer back to Pre-Check IP-3 for questions and answers.

If you did not answer correctly all questions, check with your instructor.

If you answered all four correctly, go to IP-4 (Objective) _____ .

____
Instructor's Approval

PRINCIPLES AND PRACTICES OF RE-USING ENERGY SUPPLIES

IP-4. The Recovered Product

OBJECTIVES

A. Through the study of various methods of recycling industrial residential wastes, list finished products and their value.

RESOURCES

Books:

Same as IP-3. (The Treatment of Industrial Waste, Chapter XIV)

(Recycling, Chapter III)

ACTIVITY

A. Please read the resources listed in the resource section.

B. As a result of reading the resources listed in the resource section, students will be able to plan exact use for their recyclable waste.

FEEDBACK

Objective A Check:

Refer back to IP-4 Pre-Check for questions and answers.

If you did not answer correctly all questions, check with your instructor.

If you answered all four correctly, go to the next objective.

____
Instructor's Approval

POST-CHECK

PRINCIPLES AND PRACTICES OF RE-USING ENERGY SUPPLIES

DIRECTIONS: Place a "T" for true and an "F" if the answer is false beside the question in the space provided.

IP-1. Identification of Materials

1. _____ _____ The word waste refers to materials discarded by community activities, and includes solids, liquids and gases.

2. _____ _____ Garbage is domestic or household food waste, rubbish is domestic non-food waste, and residential waste or domestic waste is the combination of garbage and rubbish.

3. _____ _____ The term recycling in its narrowest, and probably original, sense does not denote the return of a discarded material or article to the same product system.

4. _____ _____ Solid wastes, municipal refuse, industrial trash and demolition debris have a very low recovery rate.

IP-2. State Laws on Waste Disposal Must Be Observed

1. _____ _____ Recycling is the process by which recovered resources are transformed into new products in such a manner that the original products lose their identity.

2. _____ _____ Solid waste management is a purposeful, systematic control of the generation, storage, collection, transport, separation, processing, recycling, recovery and disposal of solid waste.

3. _____ _____ Senate Joint Resolution 1073 ratified April 12, 1974 appointed a four person commission to investigate and monitor all recycling requests for the state.

4. _____ _____ North Carolina has always had a comprehensive listing of persons and organizations involved in the recycling process.

IP-3. Conventional and Unconventional Methods of Handling Wastes

1. _____ _____ In the United States the early industrial waste plants were those for treatment of tannery and glue-factory wastes in Massachusetts, and they operated on the unconventional method.

2. _____ _____ One of the early American industrial-waste-treatment plants mechanically cleaned sedimentation tanks, thereby eliminating the objectionable job of removing the sludge by manual means.

3. _____ _____ The "step-sludge" method is considered conventional.

POST-CHECK

(Continued)

4. _____ _____ The unconventional methods have all been developed to reduce size and cost of waste treatment plants.

IP-4. The Recovered Product

1. _____ _____ A beer company(Coors) uses a Carver-Greenfield drying process to recover high amounts of crude protein and vitamin B-12 for subsequent use in baby formulas.

2. _____ _____ The Research Center of the Bureau of Mines has used fly ash, a by-product of electric generating plants, as a partial substitute for cement in sidewalks in Morgantown, West Virginia.

3. _____ _____ Flea markets, garage sales are methods of recycling residential waste.

4. _____ _____ Louisiana State University operated a pilot plant which fermented sugar cane bagasse into edible single cell protein competitive with soybean flour or corn meal.

MODULE TWENTY-FIVE

CAREERS IN ENERGY CONSERVATION

Prepared

by

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USDOE Sponsored Faculty Development Workshop on Energy
Conservation for IAE at North Carolina State University
June 1981-R.E. Wenig, Director

PRE-CHECK

CAREERS IN ENERGY CONSERVATION

DIRECTIONS: In the space provided, place a T in front of the statements which are True, and an F in front of those that are False.

IP-1. Types of Energy Conservation Related Occupations

1. _____ Petroleum engineers generally plan and supervise solar installation.
2. _____ Only scientists and engineers are needed in the nuclear energy field.
3. _____ An architect determines a building's interior layout to make maximum use of the sun.
4. _____ Landscape architects are trained to plant domestic landscaping to make maximum use of the sun.

IP-2. Hazards of Energy Conservation Related Occupations

1. _____ There have been more nuclear-related illnesses than any other energy conservation related occupations.
2. _____ There are no hazards related to architecture in energy conservation related jobs.
3. _____ The coal industry has a better accident record than any other energy related occupation.
4. _____ Passive solar heating is the cleanest, least hazardous method of obtaining energy.
5. _____ It makes no difference how much energy students use; there will always be plenty to accommodate everyone.

IP-3. Types of Education, Qualifications, Location and Salary

1. _____ The minimum education required for an architect is a BS from an accredited school.
2. _____ A person interested in becoming a solar energy specialist should expect to live near the equator.
3. _____ To become a coal miner, one must live in West Virginia.
4. _____ A metallurgist could find a nuclear-energy field.
5. _____ An oil research expert must move to the Middle East to find work.

IP-4. Selection of Occupation and Definition

1. _____ The United States produces more coal per year than any other nation.

2. _____ Nuclear energy is derived from the enrichment of uranium.

3. _____ Most of the energy conservation related occupations require on-the-job training.

4. _____ Computer programmers have a good opportunity for employment in energy-related jobs.

5. _____ Energy production must equal energy consumption.

6. _____ A state cannot consume energy that it does not have or cannot acquire from external sources.

PRE-CHECK KEY

CAREERS IN ENERGY CONSERVATION

IP-1. Types of Energy Conservation Related Occupations

1. F
2. F
3. T
4. T

IP-2. Hazards of Energy Conservation Related Occupations

1. F
2. F
3. F
4. T
5. T

IP-3. Types of Education-Training and Qualifications, Location and Salary in Energy Conservation

1. T
2. F
3. F
4. T
5. F

IP-4. Selection of Occupation and Definition

1. T
2. T
3. T
4. T
5. T
6. T

CAREERS IN ENERGY CONSERVATION

A student should be made aware of present, new and emerging energy-related occupations in order to make better career choices now and in the future. Armed with this information these students will be prepared to meet an ever changing world of work to accomodate the expanding need to conserve energy.

After completion of this module, select one energy conservation related occupation and describe educational requirements for entry, hazards, benefits and employment outlook for the next five years.

INSTRUCTIONAL PACKAGES		KNOW	NEED
IP-1.	Types of energy conservation related occupations	____	____
IP-2.	Hazards of energy conservation related occupations	____	____
IP-3.	Types of education-training and qualifications, location and salary	____	____
IP-4.	Selection of occupation and definition	____	____

CAREERS IN ENERGY CONSERVATION

IP-1. Types of Energy Conservation Related Occupations

OBJECTIVES

The student will be able to list five jobs in each of the following energy conservation related categories:

A.
- -Coal Industry
- -Nuclear Energy
- -Energy-related Agriculture
- -Solar Energy
- -Oil Industry
- -Education
- -Construction
- -Architecture
- -Automotive field

RESOURCES

Pamphlets:

"Occupations in Petroleum and Natural Gas Production and Gas Processing," pp. 498-500.

"Occupations in the Nuclear Energy Field," pp. 548-51.

"Coal Mining,"p. 494-97.

"Landscape Architects," pp. 470-71.

"Design Occupations-Architects," pp. 463-65.

"Agricultural Economists," pp. 489-91.

Books:

Dictionary of Occupational Titles

Information Sheet: "Job Titles in Six Energy-Related Industries"

ACTIVITY

A. Review one or more of the instructional resources listed above.

B. List energy conservation related occupations in the following categories:

Coal Industry

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________

Nuclear Energy

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________

Solar Energy

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________

Oil Industry

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________

Architecture

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________

Energy-Related Agriculture

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________

Education

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________

Automotive

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________

Construction

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________

Conservation

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________

Transportation

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________

FEEDBACK

Objective A Check:

Have your instructor check your responses in activity B.

____
Instructor Check

FEEDBACK KEY: IP-1 Answer Key

Activity B Example Answers

Coal Industry

1. Civil Engineer
2. Geologist
3. Mining Engineer
4. Fitter
5. Shot firer

Nuclear Energy

1. Electrical Engineer
2. Nuclear Physicist
3. Safety Engineer
4. Radiation Monitor
5. Machinist

Solar Energy

1. Electrical Engineer
2. Solar Engineer
3. Engineering Technician
4. Installer
5. Manufacturer

Oil Industry

1. Petroleum Engineer
2. Stratographer
3. Refining Operator
4. Driller
5. Pipefitter

Architecture

1. Civil Engineer
2. Design Engineer
3. Drafter
4. Architectural Technician
5. Engineering Technologist

Education

1. College Teacher
2. Public School Teacher
3. Industrial Trainer
4. State Energy Consultant

Automotive

1. Mechanical Engineer
2. Auto mechanic
3. Auto Parts

Energy Related Agriculture

1. Biologist
2. Biological Scientist
3. Geologist
4. Landscaper
5. Agricultural Chemist

Transportation

1. Traffic Engineer
2. State Transportation Director

Conservation

1. Energy Auditor
2. Energy Management
3. Recyling Waste, oil, etc.

Construction

1. Carpenter
2. Electrician
3. Plumber
4. Insulation Installer

CAREERS IN ENERGY CONSERVATION

IP-2 Hazards of Energy Conservation Related Occupations

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Identify at least two hazards related to energy in at least three of the following occupational categories:

- -Coal Industry
- -Nuclear Energy
- -Solar Energy
- -Oil Industry
- -Automotive
- -Construction
- -Conservation
- -Architecture
- -Energy-related Agriculture
- -Education
- -Transportation

RESOURCES

Pamphlets:

Nuclear Power and the Environment, Questions and Answers, American Nuclear Society.

Meeting Energy Workforce Needs, Sponsored by U.S. Office of Education's Energy and Education Action Center

Books:

Occupational Outlook Handbook

Filmstrips and Cassettes - Energy Information Service, Inc.
"This Precious Earth"
"Doing the eco-ethic"

ACTIVITY

A. Review one or more of the instructional resources listed above.

B. List two hazards related to the following energy conservation occupations:

1. Category ____________________________
    - a. ____
    - b. ____
2. Category ____________________________
    - a. ____
    - b. ____
3. Category ____________________________
    - a. ____
    - b. ____

FEEDBACK

Objective A Check:

1. Category - Nuclear Energy
    - a. Radioactive radon gas can be harmful to the lungs if inhaled over a number of years
    - b. Direct radiation can be deadly, but many precautions are taken including shielding, automatic alarm systems and protective clothing
2. Category - Coal Mining
    - a. Many miners have to work on their hands and knees, back or stomach when the roofs are low
    - b. There is a risk in developing pneumoconiosis (black lung) from coal dust and silicosis from the rock dust generated by the drilling in the mines.
3. Category - Oil Industry
    - a. May have to move from place to place for exploration or for drilling
    - b. Oil and gas well drilling and servicing are more hazardous than any other kinds of work. The injury rate is four times the rate for all industries in the private sector.

CAREERS IN ENERGY CONSERVATION

IP-3. Types of Education-Training Qualifications, Location and Salary

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. State the education-training, qualifications, location and potential salary for one of the following energy conservation related occupational categories:

- -Coal Industry
- -Nuclear Energy
- -Automotive
- -Conservation
- -Solar Energy
- -Oil Industry
- -Construction
- -Education
- -Architecture
- -Transportation
- -Energy-related Transportation

RESOURCES

Pamphlets:

"Nuclear Energy" by Energy Research and Development Administration (GPO-1976-219-430).

"Solar Energy for Agriculture and Industry," by (DOE/PA-0015012079).

"Professional Energy Careers," by (DOE/OPA-0C43-8-79).

"Careers in Energy Industries," by (DOE/PA-0052 1-80).

Books:

Occupational Outlook Handbook

Solar Energy-Employment and Requirements, by Department of Energy.

Filmstrips and Cassettes:
"Energy from the Wind" Ruhle
"Energy for Tomorrow" Pelham
"Energy Alternatives"
"Solar Energy"
"Nuclear Energy"

Other Resources: Listed in IP-1, and IP-2.

ACTIVITY

A. Review one or more of the instructional resources listed above.

B. Answer the following questions about your selected occupation:

1. What occupation did you choose? ______________________________
2. What kind of education-training or qualifications are required for your selected occupation? ______________________________
____
____
3. How much would it cost to become qualified in this occupation?
____
____
4. At what location could you expect to find a job in your occupation?
____
____
5. What would you expect your annual salary to be? ____________________
____

FEEDBACK

Objective A Check:

1. What occupation did you choose? Nuclear Energy

2. What kind of education training or qualifications are required for your selected occupation?

   An engineer or scientist should have advanced training in research, development, and design work. Some employers require a Ph.D. degree. Skill requirements for craft workers in the nuclear energy field are higher than in most industries because of precision required to ensure efficient operation of equipment and machinery. Pipefitters and welders must meet higher standards than in most fields. Workers operating nuclear reactor controls must be licensed by the Nuclear Regulatory Commission. Licenses are renewed every 2 years.

3. How much would it cost to become qualified in this occupation?

   Employees needing a college degree would be required to pay tuition for the duration of their education. Health physicists must have at least a B.S. degree. Radiation workers, accelerator operators, radiographers, hot cell technicians, and decontamination workers are only required to have high school diplomas and would therefore need only on-the-job training. They would encounter no expense of their own in training.

FEEDBACK cont.

4. At what location could you expect to find a job in your occupation?

   At any nuclear power plant

5. What would you expect your annual salary to be?

   In 1978, the average hourly earnings of production workers were $7.37 compared to $ 5.90 in all manufacturing industries. Scientists and engineers averaged $ 24,900 per year. Technicians averaged $ 7.54 per hour. Most hourly paid plant workers belong to unions that represent their particular craft or industry.

CAREERS IN ENERGY CONSERVATION

IP-4. Selection of Occupation and Definition of Job

OBJECTIVES

Upon completion of this instructional package, you will be able to:

A. Describe at least one of the energy conservation related occupations previously listed, and will perform an experiment related to that job.

RESOURCES

Pamphlets: Use any materials previously referred to, along with any other resources the student can locate.

Edison Publications:
"Simple Experiments on Magnetism and Electricity"
"Useful Science Projects"
"Nuclear Experiments You Can Do"
"Environmental Experiments"
"Alternative Energy Sources-Experiments You Can Do"
"Edison Experiments"

ACTIVITY

A. Review the above described resources.

B. Choose a partner from the class and select one of the following energy-related occupations:

- Coal Industry
- Nuclear Energy
- Construction
- Education
- Solar Energy
- Energy-related Architecture
- Automotive
- Architecture
- Transportation
- Conservation

Describe the requirements for job entry, the hazards related to that job, the benefits of the job and the employment outlook for the next five years. Add any other information of special interest to you or your partner.

C. With your partner, choose an experiment from one of the Edison publications listed in "resources." The experiment should coincide with your chosen energy-related occupation.

FEEDBACK

Objective A Check:

Have your teacher check your energy-related report as well as your related experiment.

POST CHECK

CAREERS IN ENERGY CONSERVATION

1. What were the results of your experiment in IP-4? Give a brief description in the space provided.

2. List three energy conservation-related occupations in the spaces provided. Include administrators, engineers, scientists, support workers, blue collar workers, and semi-skilled workers.

Coal Industry

____
____
____

Nuclear Energy

____
____
____

Solar Energy

____
____
____

Oil Industry

____
____
____

Architecture

____
____
____

Energy-Related Agriculture

____
____
____

3. Name at least two hazards to be concerned with in the above listed energy conservation-related occupations.

POST-CHECK

(Continued)

4. Give a brief summary in the space provided to describe the energy conservation-related occupation you and your partner researched in IP-4.

5. Give a general description of the education, training and qualifications necessary for the following categories concerned with energy conservation-related occupations.

   a. Administration, Engineers and Scientists

   b. Support Workers

   c. Blue Collar Workers

   d. Semi-skilled Workers